SEVERAL ESSAYS IN FINANCIAL ECONOMICS

BY

KOK CHEW LIM

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To my parents
for their selfless support of my educational goals and their unending love.

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SEVERAL ESSAYS IN FINANCIAL ECONOMICS

By

Kok Chew Lim

December, 1992

Chairman: Roy Crum
Cochairman: Haim Levy
Major Department: Finance, Insurance and Real Estate

This dissertation consists of three essays in financial economics. In essay I, price differences between the underlying Treasury securities and the portfolio of STRIPS are examined. Price differences between strippable Treasury securities and nonstrippable Treasury securities (relative to the portfolio of STRIPS) are also examined. The results show that the strippable Treasury securities are on the average priced lower than the portfolio of STRIPS. There are significant price differences between strippable and nonstrippable Treasury notes, relative to the portfolios of STRIPS. Price differences between nonstrippable Treasury notes and the equivalent portfolio of STRIPS are more variable than price differences between strippable Treasury notes and the equivalent portfolio of STRIPS, showing that stripping by

the book entry method has brought prices of strippable Treasury notes close to the price of the portfolios of STRIPS.

In essay II, the economic significance of autocorrelations in stock returns is examined. This essay examines the predictive ability of two models of stock returns: the cross-sectional autoregressive model and the autoregressive moving average model of stock returns. The out-of-sample forecasts of these models are compared to the forecasts made by the random walk model of stock prices. The results of this study show that these models do not appreciably outperform the random walk model of stocks prices. For the period between 1978 and 1990, this study shows that investors do not earn abnormal returns using the investment strategy from the cross-sectional autoregressive model. Much of the higher gains in the top portfolio, ranked based on the cross-sectional autoregressive model, can be attributed to bid-ask errors in transaction prices.

In essay III, the effect of the forward exchange bias on the gains from hedging international stock portfolios is examined from the perspectives of investors from seven countries. The performance of hedged portfolios is compared to the performance of the unhedged portfolios. The results show that the gains from hedging international investment portfolios are affected by the biasedness in the forward rates, particularly for the U.S. and Canadian investors.

CHAPTER 1
INTRODUCTION

This dissertation consists of three essays in financial economics. Essay I examines the impact of the institutional features of stripping Treasury securities on the price differences between the underlying securities and a portfolio of STRIPS with the same coupon and par value, and the price differences between strippable and nonstrippable Treasury securities, relative to the prices of the portfolios of STRIPS.[1] Strippable securities can be decomposed into STRIPS or zero coupon securities through the Federal Reserve book entry accounting system; nonstrippable securities cannot be decomposed into STRIPS.

Essay I examines three hypotheses. First, do prices of strippable and nonstrippable securities deviate from the linear price-coupon relationship set by zero-coupon prices on a particular trading day? Second, do price differences exist between the prices of strippable and nonstrippable Treasury securities (relative to their equivalent portfolio of STRIPS)? Third, are price differences between the underlying securities

[1]STRIPS refer to Separate Trading of Registered Interest and Principal of Securities.

and their equivalent portfolios of STRIPS sufficiently large for arbitrage opportunities in the Government Securities Market?

The results in Essay I show that there are significant differences between the prices of the underlying strippable securities and the portfolios of STRIPS of the same coupons and maturities. There are significant differences between the bid prices of strippable and nonstrippable securities relative to their equivalent portfolio of STRIPS, though the magnitude of the differences is small. There are relatively more arbitrage opportunities among nonstrippable notes than among strippable notes before accounting for transaction costs of stripping. Because of the lower proportion of price disparities in the strippable securities market, stripping by the book entry method has brought prices of the underlying strippable securities close to the prices of their equivalent portfolios of STRIPS.

Essay II examines the economic significance of autocorrelations in stock returns. Recent research has shown that there are significant autocorrelations in weekly, monthly and longer horizon returns. See, for example, Conrad and Kaul (1989), Jegadeesh (1990) and Fama and French (1988). These autocorrelations in stock returns are normally taken as evidence that stock returns are predictable. However, these researchers did not compare the out-of-sample predictive ability of their models with the random walk with drift model

of stock prices. The term economic significance used here refers to whether an investor can gain abnormal returns given the evidence that stock returns are autocorrelated and whether models that exhibit autocorrelations necessarily imply that their out-of-sample forecasts can outperform the random walk model of stock prices.

This essay examines the out-of-sample predictive ability of two models of stock returns: the cross-sectional autoregressive model developed by Jegadeesh (1990) and the autoregressive moving average model of stock returns developed by Conrad and Kaul (1989). The predictive ability of these models is compared with the random walk with drift model of stock prices. The best predictor using the random walk with drift model is the mean of the historical returns.

The random walk with drift model of stock prices can also be looked upon as a naive model as it uses the mean of the historical returns for prediction. The results in this essay show that the predictive ability of Jegadeesh's (1990) model does not appreciably outperform the random walk with drift model of stock prices. The autoregressive moving average model also does not appreciably outperform the random walk model of stock prices out-of-sample. An investor does not realize abnormal returns employing the investment strategy based on the cross-sectional autoregressive model.

Essay III analyzes the gains from international diversification from the perspectives of investor from

different countries. In a recent working paper, Levy and Lim (1991) analyze the gains from hedged and unhedged international portfolios from the point of view of the U.S. investor, taking into consideration that the forward rate is a biased predictor of the future spot rate. In an earlier paper, Eun and Resnick (1988) analyze the gains from hedging international portfolios based on the notion that the forward rate is a nearly unbiased predictor of the future spot rate. This notion that the forward rate is a nearly unbiased predictor of the future spot rate leads them to claim that the risk from international investments can be reduced via the forward exchange market without adversely affecting return.

However, Levy and Lim (1991) show that the unhedged international portfolios outperformed the hedged international portfolios between 1985 and 1988 when the U.S. dollar depreciated due to the fact that the forward rate underestimated the rate of depreciation of the U.S. dollar, resulting in higher mean returns from the unhedged portfolios. This essay further analyzes how the forward exchange bias affects the gains from international diversification from the perspectives of investors from different countries. I also analyze who gains the most from international diversification.

CHAPTER 2
STRIPPING OF TREASURY SECURITIES AND PRICING IN THE TREASURY SECURITIES MARKET

Background

In 1985, the Treasury began to allow coupon-bearing Treasury securities to be stripped by the Federal Reserve's book entry accounting system into zero coupon components called STRIPS.[1] The zero-coupon Treasury securities offered investors the opportunity to lock in a certain rate of return at the point of purchase. This stripping process was initiated to meet the demands of investors and institutional investors, such as pension funds, for such securities.

Since February 1985, all 10-year notes and 30-year bonds have been designated as strippable through the book entry system.[2] From here on, the term 'strippable securities' means all securities designated as strippable through the book entry system and the term 'nonstrippable securities' means all

[1] There were a few bonds issued in 1984 that were designated as strippable, eg. the 20-year 11 5/8% bonds due November 15 2004, which was issued on Oct 30 1984. These bonds are strippable after their first interest payments.

[2] Since March 1986, the Treasury has not issued any more 20-year bonds.

securities not designated as strippable through the book entry system).

Other notes of maturity shorter than 10 years or outstanding bonds issued prior to 1985 can be stripped by securities dealers by setting up trust accounts. The costs of stripping by the book entry method are much cheaper than the costs of stripping securities by the dealers themselves. Hence the dominant method of stripping now used is book entry.

STRIPS can also be rebundled or reconstituted into their original coupon-bearing security. This means that arbitrage by dealers will occur if there are disparities between the prices of STRIPS and the underlying securities.[3] Strippable bonds issued after February 1987 can be rebundled. It should be noted that nonstrippable securities may be stripped by the dealers by setting up trust accounts, but they cannot be rebundled because current Treasury regulations require that the principals from the underlying securities must be included in the portfolio of STRIPS for rebundling.

This study is carried out to better understand the pricing of STRIPS and the underlying securities in the secondary Treasury securities market. The price differences between the portfolios of STRIPS and their underlying securities are examined. I try to explain these price differences. (From here on, an equivalent portfolio of STRIPS

[3] Dealers have no tax impact from arbitrage apart from income tax on the profit.

is a portfolio having coupon components with the same coupon rate as the underlying security, and principal components with the same maturity as the underlying security.)

Research on STRIPS has attracted considerable interest recently. Livingston and Gregory (1989) show that the July 1982 change in the tax law for original issue discount securities may provide profitable opportunities for underwriters to strip U.S. Treasury securities for some term structures. For example, they show that a decomposition of an underlying bond into a portfolio of strips created an overall higher value in some cases. Duncan and Sarver (1990) attempt to test, for a tax-based clientele, the effect arising from the taxation of the accrued interest component of zeros.[4] They find a good fit between the periodic returns in the portfolio of STRIPS and the periodic returns in the underlying bonds. They argue that their results imply that the hypothesized yield differential due to the discriminatory tax treatment either does not exist, or if it exists, is arbitraged away. They perform their analysis without segregating the underlying securities into strippable and nonstrippable securities.

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[4] Current tax laws mandate that all of the return earned during a period on a zero-coupon bond (a pure capital gain) is taxable whether or not it is realized. In contrast, for a coupon-bearing bond that is not sold or whose return is not realized, only the coupon receipts are taxable. They hypothesize that the greater tax exposure of the zeros should attract tax-exempt and low bracket investors while coupon-bearing bonds should attract all others, giving rise to the clientele effect.

Objectives

I will test whether strippable securities are on the average priced lower, higher than or insignificantly different from the prices of their equivalent portfolios of STRIPS in the market. The lower price of strippable securities over their corresponding portfolios of STRIPS provides the incentives for traders to strip strippable securities. The higher price of the strippable securities over the price of the portfolios of STRIPS implies that the securities could be rebundled for a profit. The price differences between the underlying securities and their equivalent portfolios of STRIPS may not be significantly different. If the prices of the underlying strippable securities are very much lower (higher) than the prices of the equivalent portfolios of STRIPS, we would expect to see arbitrage opportunities from the purchase (sale) of strippable securities, stripping them and selling (purchasing) them as STRIPS. Hence we should not observe large price disparities between the portfolios of STRIPS and the underlying bonds in an efficient market.

I will also examine whether nonstrippable securities are on the average priced lower, higher than or insignificantly different from the prices of their equivalent portfolios of STRIPS. Nonstrippable securities cannot be rebundled as current institutional features require that principals STRIPS be from the underlying bond for rebundling. As nonstrippable

securities cannot be rebundled, the higher price of the nonstrippable securities over the equivalent portfolios of STRIPS, if it occurs, cannot be due to the profitability to rebundle STRIPS into the nonstrippable securities. If the underlying nonstrippable securities are on the average priced higher than the portfolios of STRIPS, it implies that the portolios of STRIPS do not, on the average, command a higher premium than the underlying nonstrippable securities. This means that it is not profitable to strip the nonstrippable securities. This objective to examine if there are price differences between the underlying securities and the portfolios of STRIPS is equivalent to the objective to examine as to whether the prices of the underlying securities are a linear function of the coupons.

The second objective of this study is to examine if there are price differences between the strippable and nonstrippable securities (relative to their equivalent portfolios of STRIPS).

The third objective of this paper is to investigate whether there are arbitrage opportunities in the government bond market. In particular, we will test whether dealers can buy (sell) portfolios of STRIPS at the lower (higher) price and sell (buy) the strippable or nonstrippable coupon-bearing bonds at the higher (lower) price. It is expected that arbitrage opportunities are extremely rare in the market. However, this is done to see if there are more price

disparities for the sample of nonstrippable securities than for the sample of strippable securities.

Further Institutional Features on Stripping of Treasury Securities.

Current institutional features on stripping bonds require that enough bonds be included in a packet of bonds to produce coupon STRIPS in $1,000 multiples. For example, the minimum number of 10% coupon semi-annual bonds required in stripping is 20. A single coupon STRIP on each coupon payment date has a face value of $1,000 which means that a total of $2,000 of interest is paid annually. This requires a total of $20,000 worth of principal, which means that 20 bonds are required and that also translates into 20 principal strips.[5] For a 9.875% bond, we would require a minimum of 1600 bonds. This translates into $1,600,000 worth of principal and $158,000 worth of interest annually. On a coupon payment date, we would have $79,000 worth of interest paid out or the equivalent of 79 coupon strips.

---

[5] Actually, to solve for the minimum number of coupon strips, N is to solve the following equation iteratively:

$$(C/2)x = 1000\ N$$

where N is the number of coupon strips, C is the coupon in dollars per $1000 par value and x is the first integer that is obtained as N, an integer, increases. For eg., for a 9.875 % bond, we would require a minimum of 79 coupon strips. On a coupon payment date, we would have $79,000 worth of interest paid out. This translates into $158,000 worth of interest annually or $1,600,000 worth of principal.

Profits from Stripping

Livingston and Gregory (pg. 33-50, 1989) demonstrate that profits from stripping will occur for rising yield curves and that long maturity bonds will be most profitable to strip. They provide an example as to when profits from stripping may occur. They show that rising term structure causes the portfolios of strips to have higher total after-tax cash flows and higher present value of after-tax cash flows at points that are closer to the trading day of the security. Also, the profits become larger the longer the maturity of the security.

Data and Methodology

Data

The primary source of data is The Wall Street Journal. The Wall Street Journal reports the prices of both principal STRIPS and coupon STRIPS.[6] The number of strippable and nonstrippable Treasury securities included in the sample on a particular trading day is shown in Table 2-1. The principal STRIPS prices are used when calculating the price of the par value in the portfolio of STRIPS. To be of use in the comparisons of prices of the underlying securities and the portfolio of STRIPS, the zero-coupon prices and the underlying bond prices should be quoted synchronously or simultaneously.

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[6] The Wall Street Journal obtains these price quotations from Bear Stearns.

These prices are quoted simultaneously according to a bond trader at Bear Stearns.

When calculating the prices of the portfolios of STRIPS, it is necessary to use the prices of the principal zeros. This is because the prices of the principal components are on the average higher than the prices of the coupon components.[7] If the prices of the coupon components were to be used in lieu of the prices of the principal components, a correct price of the portfolios of STRIPS that is equivalent to the nonstrippable securities would not be attained. This leads to a problem when calculating the prices of the portfolios of STRIPS that are equivalent to the nonstrippable securities as these nonstrippable securities do not have principal components traded separately (as they were not strippable).

In our sample, there are only six nonstrippable securities (all notes) that have the same maturity as the strippable securities. Hence we can only calculate the prices of the portfolio of STRIPS for six nonstrippable securities. Owing to the existence of this data problem, I can only examine in this study, price differences between the prices of strippable and nonstrippable notes (bonds not included).

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[7] The reasons why this may occur are discussed in a working paper by Daves and Ehrhardt (1991).

TABLE 2-1
NUMBER OF STRIPPABLE AND NONSTRIPPABLE TREASURY SECURITIES INCLUDED IN THE SAMPLE ON A PARTICULAR TRADING DAY.

Treasury securities	Maturity months: February & August	Maturity months: May & November
strippable	19	21
nonstrippable	2	4

Note:

The low number of nonstrippable securities in the sample is due to the small number of nonstrippable securities which have the same maturity as the strippable securities. This is important because the prices of the principal STRIPS are required to calculate the prices of the portfolios of STRIPS.

To test whether underlying Treasury security prices is a linear function of coupon

The linear relationship between underlying bond prices and coupon for n-period bonds is postulated as

$$P = C[\sum_{i=1}^{n} S_i] + Par(S_n) \qquad (2.1)$$

where

P = underlying bond price S_i = STRIPS price

C = coupon

The whole term on the right-hand side of (2.1) is the price of the portfolio of STRIPS having the same coupon and par value as a coupon-bearing bond. If (2.1) is true, the underlying bond price is a linear function of C.

The prices of the underlying securities are calculated and compared to a portfolio of STRIPS with the same coupon and par value. The bid and ask prices of the portfolio of STRIPS (denoted as S.B and S.A respectively) are calculated and compared to the bid and ask prices of the underlying securities (denoted as U.B and U.A respectively). This is done for both the strippable and nonstrippable securities.[8] To obtain the observed market bid and ask prices of the underlying securities when trading days do not fall on the

[8] Ideally what is desired are the transaction prices of the underlying bonds and STRIPS. However, because I cannot gain access to these data, I perform this analysis using the bid and ask prices for these bonds as quoted in The Wall Street Journal.

semiannual coupon dates, the accrued interest is added to the quoted bid or ask prices,

$$U.B = U.B_q + C/2(t_{1s}/B) \tag{2.2}$$

$$U.A = U.A_q + C/2(t_{1s}/B) \tag{2.3}$$

where $U.B_q$ and $U.A_q$ are the quoted bid and ask prices respectively, t_{1s} is the number of days between the last coupon date and the settlement date, C is the annual coupon and B is the number of days between coupon dates. On the semiannual coupon dates, the quoted bid and ask prices are the observed market prices of the underlying securities.[9]

A source at Bear Stearns has indicated that the prices quoted in The Wall Street Journal are for settlement the following day after the close of the trading. However, the number of days between the last coupon date and the settlement day is calculated from the last coupon date to the trading day.

The bid (ask) prices of an underlying bond are compared with the bid (ask) prices of the portfolio of STRIPS for strippable and nonstrippable securities. The price differences, dif_b and dif_a are obtained, where dif_b and dif_a are given by

$$dif_b = U.B - S.B \tag{2.4}$$

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[9] The months in which treasury securities in stripped form mature are February, May, August and November and this means that zero-coupon bonds also mature in those months. Hence our coverage of this study is confined to analyzing strippable and nonstrippable bonds which mature in February, May, August and November.

$$dif_a = U.A. - S.A \tag{2.5}$$

The relative differences R_b and R_a are given by

$$R_b = dif_b/S.B \tag{2.6}$$

$$R_a = dif_a/S.A \tag{2.7}$$

The means of R_a and R_b, $\mu(R_a)$ and $\mu(R_b)$, respectively, are obtained for the whole sample of strippable and nonstrippable securities. If R_a and R_b are significantly differently from zero, this shows that there are differences between the prices of the underlying securities and the portfolios of STRIPS, which means that the underlying Treasury security prices are not a linear function of coupons.

To Test for Price Differences Between Strippable and Nonstrippable Securities (Relative to Their Equivalent Portfolio of STRIPS)

To analyze whether there are price differences between strippable and nonstrippable securities, $\mu(R_b)$ for strippable securities, denoted as $\mu(R_{bs})$, will be compared to $\mu(R_b)$ for nonstrippable securities, denoted as $\mu(R_{bns})$. The difference between $\mu(R_{bs})$ and $\mu(R_{bns})$ is obtained and tested for its statistical significance. If $\mu(R_{bs}) - \mu(R_{bns})$ is significantly greater than zero, this implies that equivalent portfolios of STRIPS have lower prices than the strippable underlying securities as compared to the prices of the portfolio of STRIPS over the prices of the nonstrippable underlying securities. In other words, it shows that the portfolios of STRIPS derived from the underlying strippable securities have

lower prices than the portfolios of STRIPS derived from the underlying nonstrippable securities.

If $\mu(R_{bs})$ - $\mu(R_{bns})$ is significantly less than zero, this implies that equivalent portfolios of STRIPS have higher prices than the strippable securities as compared to the prices of the portfolio of STRIPS over the prices of the nonstrippable securities. This price difference implies it is relatively more worthwhile on the average for the dealers to strip the strippable securities. The lesser price of the portfolios of STRIPS than their equivalent nonstrippable securities implies that it is on the average less worthwhile for dealers to strip the nonstrippable securities due possibly to the larger costs in stripping nonstrippable securities. The same procedure detailed above is also repeated for the ask price counterpart.

It is also hypothesized that because it is harder for dealers to carry out arbitrage between the underlying nonstrippable securities and the portfolio of STRIPS, the variance of the price differences between the nonstrippable securities and the portfolios of STRIPS is higher than the variance of the price differences between the strippable securities and the portfolios of STRIPS. In other words, one would expect that the ease of stripping by the book entry method would bring prices of the strippable securities closer to the prices of the portfolios of STRIPS than for the case of the nonstrippable securities.

To test for arbitrage between STRIPS and underlying securities

This section tests whether dealers can make arbitrage profits by buying (selling) a portfolio of STRIPS at the lower (higher) price and selling (buying) the strippable coupon-bearing securities. The same tests will be run for nonstrippable securities. Apparent arbitrage profits may result from errors in prices in the Wall Street Journal. Nevertheless, the significance of the arbitrage profits is examined by looking at the frequency distribution of the profits. Specifically I calculate the proportions of our test sample which contain arbitrage profits (abbreviated as pr) which lie between the following ranges:

a. pr = $ 0.00
b. 0 < pr =< 0.1
c. 0.1 < pr =< 0.3
d. 0.3 < pr =< 0.5
e. 0.5 < pr =< 0.7
f. 0.7 < pr

The above distributions of profits for each trading day are reported. The absence of arbitrage opportunities implies that there is a linear relationship between price and coupon for a particular maturity. Note that the arbitrage between STRIPS and coupon-bearing securities can be carried out by dealers without taxation of the coupons. Dealers are taxed only on the profit they make from the arbitrage.

The Prices of STRIPS versus the Underlying Securities - Graphical Illustrations

Figures 1 through 6 illustrate the five possible comparisons of the bid and ask prices of STRIPS and underlying securities:

Case 1: P1 = S.B - U.A. P1 > 0 (There is arbitrage).

Case 2: P2 = U.B. - S.A. P2 > 0 (There is arbitrage).

Case 3: If S.A > U.A and S.B > U.B, but U.A > S.B then Case 3 (No arbitrage).

Case 4: If U.A > S.A and U.B > S.B, but S.A > U.B then Case 4 (No arbitrage).

Case 5: If U.A > S.A and S.B > U.B, then Case 5 (No arbitrage).

Case 6: If S.A > U.A and U.B > S.B then Case 6 (No arbitrage).

The following two cases, Case 7 and Case 8, includes combinations of some of the above cases:

Case 7: If S.A > U.A and S.B > U.B then Case 7 (which includes Cases 1 and 3).

Case 8: If U.A > S.A and U.B > S.B then Case 8 (which includes Cases 2 and 4).

For Case 1 and Case 2, there are arbitrage opportunities. The arbitrage for Case 1 can be carried out by purchasing the underlying security at the ask price and selling them as STRIPS at the bid price. The arbitrage for Case 2 can be carried out by purchasing the portfolio of STRIPS at the ask price, rebundling them and selling this portfolio at the

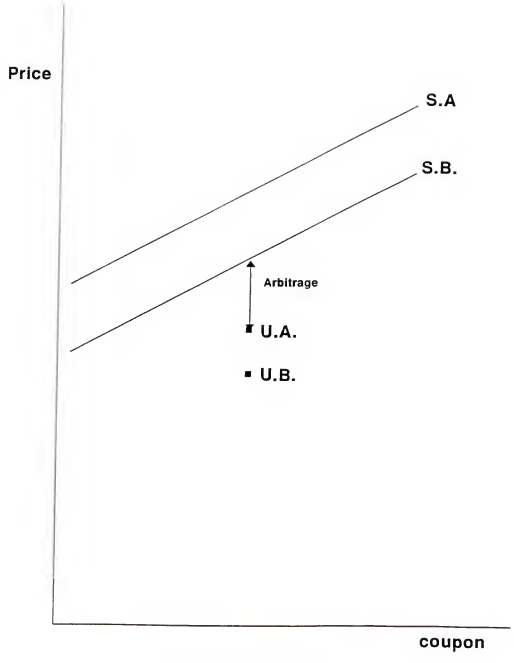

Figure 1. Case 1

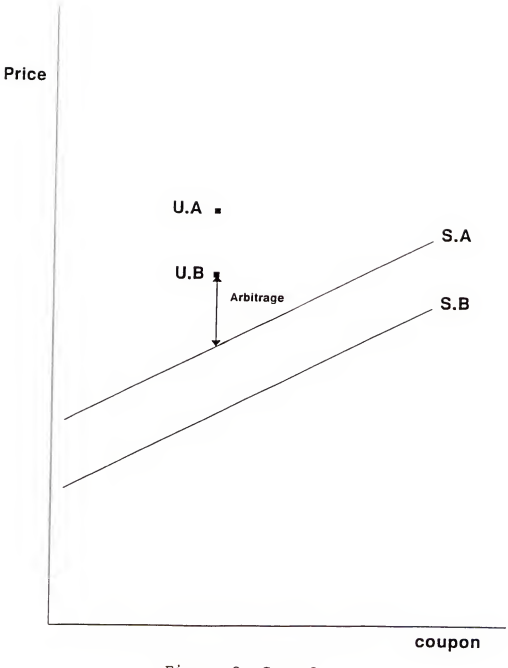

Figure 2. Case 2

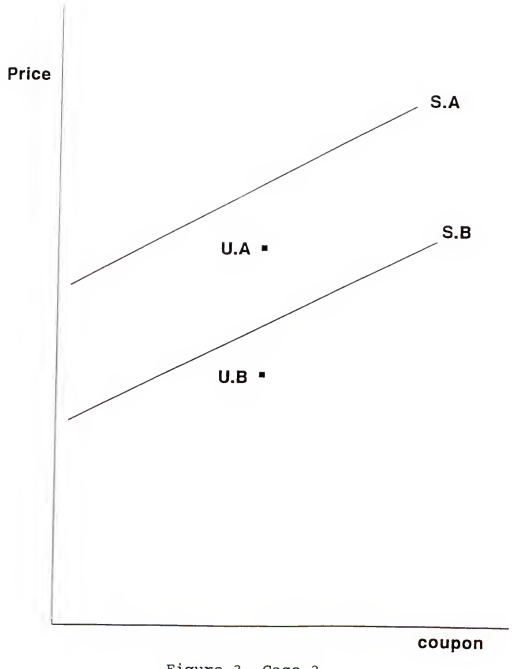

Figure 3. Case 3

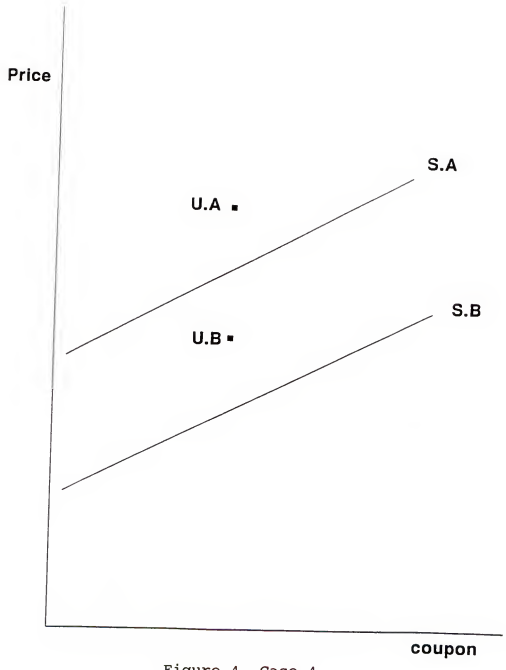

Figure 4. Case 4

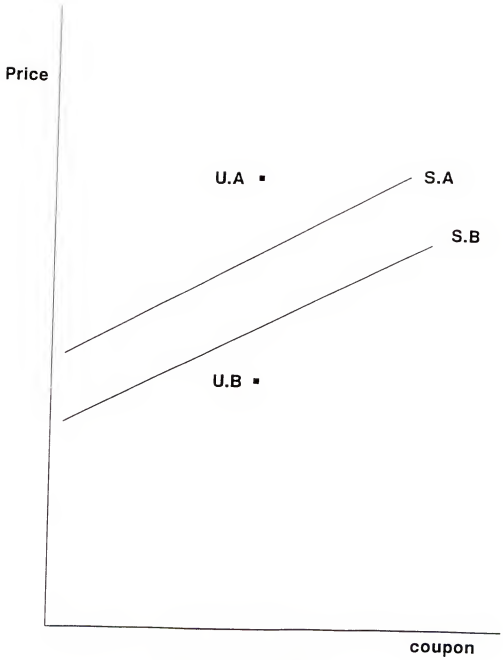

Figure 5. Case 5

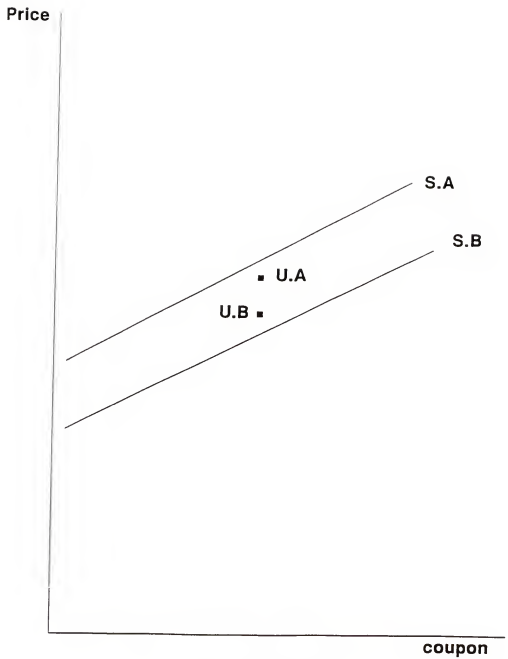

Figure 6. Case 6

underlying security bid price. For Cases 3, 4 and 5, there are no arbitrage opportunities. Case 1 and Case 3 are subsets of Case 7. Case 2 and Case 4 are subsets of Case 8. Note that Cases 1 through 6 are mutually exclusive. In the empirical results, the number reported under Case 7 is the sum of the number of securities which fall into Case 1 and Case 3. Similarly, the number reported under Case 8 is the sum of the number of securities which fall into Case 2 and Case 4.

For nonstrippable and strippable securities, this research will report the number and size of arbitrage opportunities for each date, for each security (over several dates), and for all dates and securities aggregated. If the market for nonstrippable securities is segmented, there should be more arbitrage opportunities for nonstrippable securities and these should persist over time. This is because it costs more to strip nonstrippable securities and it is also impossible to rebundle portfolios of STRIPS into nonstrippable securities.

Results

Strippable Securities vs. Portfolios of STRIPS

Table 2-2A reports the mean differences in prices between the aggregate of all strippable securities in our sample and the portfolio of STRIPS. The results show that the bid prices of the strippable securities are significantly lower than the bid prices of the portfolios of STRIPS but the mean difference

is small, about 1.7 cents (per $100 face value) lower than the average bid price of the portfolio of STRIPS. However the ask prices of the strippable securities are on the average 12 cents lower (per $100 face value) than the average ask price of the portfolio of STRIPS. The ask prices of the strippable securities in the aggregate are significantly lower (at the 0.5 % level) than the corresponding portfolios of STRIPS. Tables 2-2B and C breaks the results down for bonds and notes. Table 2-2B reports the mean differences in prices between the sample of strippable bonds only and the portfolios of STRIPS. The results show that the bid and ask prices of the strippable bonds are significantly lower than the corresponding bid and ask prices of the equivalent portfolios of STRIPS. The bid and ask prices of the strippable bonds are on the average about 4 cents and 22 cents lower than the bid and ask prices of the equivalent portfolios of STRIPS respectively.

Table 2-2C reports the mean differences in prices between the sample of strippable notes only and the portfolios of STRIPS. The bid prices of the strippable notes are not significantly different than the corresponding bid prices of the portfolios of STRIPS. The ask prices of the strippable notes, however, are significantly lower than the prices of the portfolios of STRIPS but the magnitude is small, about 3 cents (per $100 face value) lower.

These results for the sample of strippable securities indicate that the strippable securities are on the average

priced lower than the equivalent portfolios of STRIPS, more so for securities of longer maturity. These results support the descriptions in Livingston and Gregory (1989) that when the term structure is rising (which is the case for the sample period for this study), the portfolios of STRIPS command a higher price over the underlying strippable securities.

The breakdown of the cases into which the strippable securities fall by trading day is given in Table 2-3. The results in Table 2-3 reaffirm the results in Table 2-2. The results in Table 2-3 show that most of the strippable securities (about 62.8%) fall into Case 7 (which is the case when the bid and ask prices of the portfolios of STRIPS are above the corresponding bid and ask prices of the underlying securities). There are other cases (which includes Cases 5 and 6) when either one of the bid and ask prices of the portfolios of STRIPS is priced higher than the bid and ask prices of the underlying securities.

Table 2-4 provides the number of arbitrage opportunities and the amount of profit, if any, from carrying out these arbitrage opportunities. For 61% of the time, there are no arbitrage opportunities (Group A). There appears to be profits as shown in Groups B, C, D and E. The profits from Group B would have been wiped out after accounting for transaction costs. The profits in Groups C, D and E are rare and it is not clear whether these transactions can be executed

simultaneously, hence they may not be riskless.

Nonstrippable securities vs. Porftolio of STRIPS

The results in Table 2-5 show that the bid and ask prices of the nonstrippable notes are significantly higher than the prices of the portfolios of STRIPS. The bid and ask prices of the nonstrippable notes are on the average about eight and four cents respectively above the prices of the underlying securities. Table 2-7 provides the case breakdown for this sample of nonstrippable securities. Table 2-8 provides the frequency of arbitrage profits and the magnitude of the profits of the nonstrippable securities.

Strippable vs. Nonstrippable notes

Table 2-6 shows that the variance of the price differences between the prices of the nonstrippable securities and the equivalent prices of the portfolios of STRIPS are higher than the variance of the price differences between the prices of strippable securities and the equivalent prices of the portfolios of STRIPS. This larger variance for the sample of nonstrippable securities shows that the ease of stripping by the book entry method has resulted in lower variability of the price differences between prices of the portfolios of STRIPS and the underlying strippable securities.

Table 2-9 shows that the mean of the differences between the prices of the strippable securities and the portfolio of STRIPS are significantly lower than the mean of the

TABLE 2-2
TEST FOR SIGNIFICANT DIFFERENCES BETWEEN THE PRICES OF UNDERLYING STRIPPABLE TREASURY SECURITIES AND THE PORTFOLIO OF STRIPS

A. Sample of all Strippable Securities

	Strippable	
	Bid	Ask
Mean[a]	-0.01727	-0.12206
Number	640	640
Std dev	0.172	0.203
t (U-S)	-2.54*	-15.24**

B. Strippable Bonds only

	Strippable	
	Bid	Ask
Mean	-0.04448	-0.22572
Number	288	288
Std dev	0.193	0.202
t	-3.91**	-18.97**

C. Strippable Notes only

	Strippable	
	Bid	Ask
Mean	0.00499	-0.0372
Number	352	352
Std dev	0.149	0.159
t	0.63	-4.39**

Note:

* Significant at the 1 % level.
** Significant at least at the 0.5% level.

[a] Mean refers to the mean of ((U-S)/S), where:
U = Underlying Treasury security price,
S = Price of Portfolio of STRIPS.
t = t-statistic
Std dev = Standard deviation

TABLE 2-3
BREAKDOWN OF CASES IN WHICH STRIPPABLE SECURITIES BELONG ON EACH TRADING DAY

	Trading day	Case								
		1	2	3	4	5	6	7	8	total
1	Aug 15 90	7	13	11	6	0	3	18	19	40
2	Aug 27 90	4	10	13	7	1	5	17	17	40
3	Nov 15 90	11	1	15	8	0	5	26	9	40
4	NOv 23 90	9	3	17	5	0	6	26	8	40
5	Dec 10 90	6	2	14	1	0	17	20	3	40
6	Dec 24 90	12	1	19	7	0	1	31	8	40
7	Dec 31 90	24	1	10	3	0	2	34	4	40
8	Jan 14 91	7	7	20	6	0	0	27	13	40
9	Jan 28 91	4	7	19	7	0	3	23	14	40
10	Feb 1 91	21	10	4	3	0	2	25	13	40
11	Feb 15 91	10	2	22	4	0	2	32	6	40
12	Feb 25 91	5	3	19	2	0	11	24	5	40
13	Mar 4 91	3	1	18	8	1	9	21	9	40
14	Ap 15 91	4	4	9	5	0	18	13	9	40
15	May 10 91	28	1	4	1	0	6	32	2	40
16	May 28 91	25	3	8	0	0	4	33	3	40
Total		180	69	222	73	2	94	402	142	640
% of grand total		28.1	10.8	34.7	11.4	0.3	14.7	62.8	22.2	1
% of grand total showing arbitrage (Case 1 + Case 2) = 39										

Table 2-3--continued

Notes:

Case 1: P1 = S.B - U.A. P1 > 0 (There is arbitrage).
Case 2: P2 = U.B. - S.A. P2 > 0 (There is arbitrage).
Case 3: If S.A > U.A and S.B > U.B, but U.A > S.B then Case 3 (No arbitrage).
Case 4: If U.A > S.A and U.B > S.B, but S.A > U.B then Case 4 (No arbitrage).
Case 5: If U.A > S.A and S.B > U.B, then Case 5 (No arbitrage).
Case 6: If S.A > U.A and U.B > S.B then Case 6 (No arbitrage).
Case 7: If S.A > U.A and S.B > U.B then Case 7 (which includes Cases 1 and 3).
Case 8: If U.A > S.A and U.B > S.B then Case 8 (which includes Cases 2 and 4).

S.B and S.A denote bid and ask prices of portfolios of STRIPS. U.B and U.A denote bid and ask prices of the underlying securities. The percentages of grand total for Cases 1 through 6 must add up to 100%.

TABLE 2-4
THE FREQUENCY OF ARBITRAGE PROFITS FOR STRIPPABLE SECURITIES ON EACH TRADING DAY

	Trading day	A	B	C	D	E	F	Sum
1	Aug 15 90	20	7	11	1	0	1	40
2	Aug 27 90	26	6	8	0	0	0	40
3	Nov 15 90	28	11	1	0	0	0	40
4	NOv 23 90	28	11	1	0	0	0	40
5	Dec 10 90	32	6	0	1	1	0	40
6	Dec 24 90	27	10	3	0	0	0	40
7	Dec 31 90	15	18	6	1	0	0	40
8	Jan 14 91	26	10	4	0	0	0	40
9	Jan 28 91	29	9	2	0	0	0	40
10	Feb 1 91	9	13	17	0	0	1	40
11	Feb 15 91	28	9	1	1	0	1	40
12	Feb 25 91	32	5	2	1	0	0	40
13	Mar 4 91	36	2	1	1	0	0	40
14	Ap 15 91	32	5	1	1	1	0	40
15	May 10 91	11	19	10	0	0	0	40
16	May 28 91	12	19	8	1	0	0	40
Total		391	160	76	8	2	3	640
% of Grand Total		61	25	12	1.2	0.3	0.5	1
% of grand total showing arbitrage = 39								

Note:
The arbitrage profits in $ are divided into these groups:

A: No Profit ($0.00)
B: 0.0 < Profit =< 0.1
C: 0.1 < Profit =< 0.3
D: 0.3 < Profit =< 0.5
E: 0.5 < Profit =< 0.7
F: 0.7 < Profit

TABLE 2-5
TEST FOR SIGNIFICANT DIFFERENCES BETWEEN THE PRICES OF UNDERLYING TREASURY NOTES AND THE PORTFOLIO OF STRIPS

	Strippable		Nonstrippable	
	Bid	Ask	Bid	Ask
Mean	-0.00081	-0.002	0.0791	0.0367
Number	80	80	94	94
Std dev	0.0983	0.1095	0.1966	0.2097
t	-0.07	-0.16	3.90**	1.69*

* Significant at the 5% level.
** Significant at least at the 0.5% level.

[a] Mean refers to the mean of ((U-S)/S), where
U = Underlying Treasury security price,
S = Price of Portfolio of STRIPS.
t = t-statistic
Std dev = Standard deviation

TABLE 2-6
F-TEST FOR EQUALITY OF VARIANCES BETWEEN THE VARIANCE OF NONSTRIPPABLE AND STRIPPABLE NOTES

	Bid-Bid	Ask-Ask
F stat.	4.0*	3.67*

* significant at the 0.5% level.

The numerator in the F-statistic is the variance of the nonstrippable notes and the denominator is the variance of the strippable notes.

TABLE 2-7
CASE BREAKDOWN FOR NONSTRIPPABLE SECURITIES: SAMPLE WITH SAME MATURITY AS THOSE OF STRIPPABLE NOTES

	Trading day	Case								
		1	2	3	4	5	6	7	8	Total
1	Au 15 90	0	3	0	2	0	0	0	5	5
2	Au 27 90	0	3	1	1	0	0	1	4	5
3	No 15 90	1	3	1	1	0	0	2	4	6
4	Nov 23 90	1	1	1	3	0	0	2	4	6
5	Dec 10 90	1	2	1	1	0	1	2	3	6
6	Dec 24 90	1	3	1	0	0	1	2	3	6
7	Dec 31 90	1	3	1	0	0	1	2	3	6
8	Jan 14 91	1	3	2	0	0	0	3	3	6
9	Jan 28 91	1	2	1	1	0	1	2	3	6
10	Feb 1 91	1	2	1	1	0	1	2	3	6
11	Feb 15 91	1	3	0	1	0	1	1	4	6
12	Feb 25 91	0	3	1	1	0	1	1	4	6
13	Mar 4 91	0	2	2	1	0	1	2	3	6
14	Ap 15 91	1	2	1	1	0	1	2	3	6
15	May 10 91	3	0	1	0	0	2	4	0	6
16	May 28 91	2	2	0	1	0	1	2	3	6
Total		15	37	15	15	0	12	30	52	94
% of grand total[a]		16.0	39.4	16.0	16.0	0	12.8	31.9	55.3	1
% of grand total showing arbitrage (Case 1 + Case 2) = 55.4										

Table 2-7--continued

[a] The total percentages do not add up to 100 due to rounding errors.

Notes:

Case 1: P1 = S.B - U.A. P1 > 0 (There is arbitrage).
Case 2: P2 = U.B. - S.A. P2 > 0 (There is arbitrage).
Case 3: If S.A > U.A and S.B > U.B, but U.A > S.B then Case 3 (No arbitrage).
Case 4: If U.A > S.A and U.B > S.B, but S.A > U.B then Case 4 (No arbitrage).
Case 5: If U.A > S.A and S.B > U.B, then Case 5 (No arbitrage).
Case 6: If S.A > U.A and U.B > S.B then Case 6 (No arbitrage).
Case 7: If S.A > U.A and S.B > U.B then Case 7 (which includes Cases 1 and 3).
Case 8: If U.A > S.A and U.B > S.B then Case 8 (which includes Cases 2 and 4).

S.B and S.A denote bid and ask prices of portfolios of STRIPS. U.B and U.A denote bid and ask prices of the underlying securities. The percentages of grand total for Cases 1 through 6 must add up to 100%.

TABLE 2-8
THE FREQUENCY OF ARBITRAGE PROFITS FOR NONSTRIPPABLE NOTES ON EACH TRADING DAY: SAMPLE WITH SAME MATURITY AS THOSE OF STRIPPABLE NOTES

		Group						
	Trading day	A	B	C	D	E	F	Sum
1	Au 15 90	2	0	3	0	0	0	5
2	Au 27 90	2	2	1	0	0	0	5
3	No 15 90	2	4	0	0	0	0	6
4	Nov 23 90	4	1	0	0	1	0	6
5	Dec 10 90	3	3	0	0	0	0	6
6	Dec 24 90	2	3	1	0	0	0	6
7	Dec 31 90	2	2	2	0	0	0	6
8	Jan 14 91	2	1	3	0	0	0	6
9	Jan 28 91	3	1	2	0	0	0	6
10	Feb 1 91	3	0	3	0	0	0	6
11	Feb 15 91	2	2	2	0	0	0	6
12	Feb 25 91	3	2	1	0	0	0	6
13	Mar 4 91	4	1	1	0	0	0	6
14	Ap 15 91	3	1	1	0	1	0	6
15	May 10 91	3	2	1	0	0	0	6
16	May 28 91	2	4	0	0	0	0	6
Total		42	29	21	0	2	0	94
% of grand total		45	31	22	0	2	0	1
% of grand total with arbitrage profits = 55								

Note:
The arbitrage profits in $ are divided into these groups:

A: No Profit ($0.00)
B: 0.0 < Profit =< 0.1
C: 0.1 < Profit =< 0.3
D: 0.3 < Profit =< 0.5
E: 0.5 < Profit =< 0.7
F: 0.7 < Profit

TABLE 2-9
TEST FOR DIFFERENCES BETWEEN THE PRICES OF STRIPPABLE AND NONSTRIPPABLE TREASURY NOTES (RELATIVE TO THEIR PORTFOLIOS of STRIPS)

(Welch's Test for differences in the means).

	Bid-Bid	Ask-Ask
$\mu_{US} - \mu_{UNS}$	-0.0799	-0.039
t(Notes)	-2.82**	-1.56

** Significant at least at the 0.5 % level.

Note:
The t-statistics reported above test whether the differences in the means, ($\mu_{US} - \mu_{UNS}$) are significantly greater or less than zero, where

μ_{US} = the mean of (US-S)/S, and
μ_{UNS} = the mean of (UNS-S)/S. US is the price of the strippable Treasury securities, UNS is the price of the nonstrippable securities, S is the corresponding price of the portfolio of STRIPS.

TABLE 2-10
CASE BREAKDOWN FOR STRIPPABLE SECURITIES: SAMPLE WITH SAME MATURITY AS THOSE OF NONSTRIPPABLE NOTES

	Trading day	Case								Total
		1	2	3	4	5	6	7	8	
1	Au 15 90	0	2	0	3	0	0	0	5	5
2	Au 27 90	0	1	0	3	1	0	0	4	5
3	No 15 90	1	0	2	2	0	0	3	2	5
4	Nov 23	0	0	5	0	0	0	5	0	5
5	Dec 10	0	0	4	1	0	0	4	1	5
6	Dec 24	0	0	2	3	0	0	2	3	5
7	Dec 31	0	0	3	2	0	0	3	2	5
8	Jan 14	0	2	3	0	0	0	3	2	5
9	Jan 28	0	1	3	1	0	0	3	2	5
10	Feb 1 91	1	2	2	0	0	0	3	2	5
11	Feb 15	0	1	2	2	0	0	2	3	5
12	Feb 25	0	1	2	2	0	0	2	3	5
13	Mar 4 91	0	0	2	2	1	0	2	2	5
14	Ap 15 91	2	2	1	0	0	0	3	2	5
15	May 10	4	0	1	0	0	0	5	0	5
16	May 28	2	0	1	0	0	2	3	0	5
	Total	10	12	33	21	2	2	43	33	80
% of grand total[a]		12.5	15	41.3	26.3	2.5	2.5	53.8	41.3	1
% of grand total showing arbitrage profits (Case 1 + Case 2) = 27										

Table 2-10--continued

[a] The total percentages do not add up to 100 owing to rounding errors.

Notes:

Case 1: P1 = S.B - U.A. P1 > 0 (There is arbitrage).
Case 2: P2 = U.B. - S.A. P2 > 0 (There is arbitrage).
Case 3: If S.A > U.A and S.B > U.B, but U.A > S.B then Case 3 (No arbitrage).
Case 4: If U.A > S.A and U.B > S.B, but S.A > U.B then Case 4 (No arbitrage).
Case 5: If U.A > S.A and S.B > U.B, then Case 5 (No arbitrage).
Case 6: If S.A > U.A and U.B > S.B then Case 6 (No arbitrage).
Case 7: If S.A > U.A and S.B > U.B then Case 7 (which includes Cases 1 and 3).
Case 8: If U.A > S.A and U.B > S.B then Case 8 (which includes Cases 2 and 4).
S.B and S.A denote bid and ask prices of portfolios of STRIPS.
U.B and U.A denote bid and ask prices of the underlying securities.
The percentages of grand total for Cases 1 through 6 must add up to 100%.

TABLE 2-11
BREAKDOWN OF PROFITS IN WHICH STRIPPABLE SECURITIES BELONG ON EACH TRADING DAY: SAMPLE WITH SAME MATURITY AS THOSE OF NONSTRIPPABLE NOTES

		Group						
	Trading day	A	B	C	D	E	F	Sum
1	Au 15 90	3	2	0	0	0	0	5
2	Au 27 90	4	1	0	0	0	0	5
3	No 15 90	4	1	0	0	0	0	6
4	Nov 23 90	5	0	0	0	0	0	6
5	Dec 10 90	5	0	0	0	0	0	6
6	Dec 24 90	5	0	0	0	0	0	6
7	Dec 31 90	5	0	0	0	0	0	6
8	Jan 14 91	3	2	0	0	0	0	6
9	Jan 28 91	4	1	0	0	0	0	6
10	Feb 1 91	2	0	3	0	0	0	6
11	Feb 15 91	4	0	1	0	0	0	6
12	Feb 25 91	4	0	1	0	0	0	6
13	Mar 4 91	5	0	0	0	0	0	6
14	Ap 15 91	1	3	1	0	0	0	6
15	May 10 91	1	2	2	0	0	0	6
16	May 28 91	3	2	0	0	0	0	6
Total		58	14	8	0	0	0	80
% of grand total		72.5	17.5	10	0	0	0	1
% of grand total with arbitrage profits = 27.5								

Note:
The arbitrage profits in $ are divided into these groups:
A: No Profit ($0.00)
B: 0.0 < Profit =< 0.1
C: 0.1 < Profit =< 0.3
D: 0.3 < Profit =< 0.5
E: 0.5 < Profit =< 0.7
F: 0.7 < Profit

differences between the prices of the nonstrippable securities and the portfolio of STRIPS.[10] Comparisons between Table 2-7 and Table 2-10, where breakdown of the cases in which the strippable notes of the same maturity belong show that there is a higher proportion of arbitrage opportunities for the nonstrippable securities than for the strippable securities. Also, comparisons between Table 2-8 and Table 2-11 (the case for the strippable notes of the same maturity as those of the nonstrippable notes) show that the magnitude of the apparent arbitrage profits are higher for the nonstrippable notes than for the strippable notes. These results reaffirm the hypothesis that the institutional feature of book entry stripping has brought prices closer in line for the strippable securities.

Further Analysis Using Regressions

Given that there are significant differences in the prices between the underlying strippable securities and the portfolio of STRIPS, I examine further variables that may be related to these differences. Several variables that may relate to these differences are listed below:

1) maturity of the bonds.

2) the minimum number of bonds required for stripping. This is obtained knowing the coupon rate (Please see the section,

[10] As the variance of the price differences between the two groups were significantly different, we use the Welch's Test to test for differences in the means.

"Further Institutional Features on Strippng of Treasury Securities" for details on how to calculate that minimum number of bonds for stripping).

3) whether, within the sample of strippable securities, the strippable securities are rebundable (dummy variables are used: 1 if non-rebundable and 0 if rebundable).

It would be of interest to examine whether the volume of securities traded may account for these differences but this data is not accessible. The following provides a description as to how the variables listed above may be related to these price differences:

X1 = the minimum number of bonds required for stripping. I expect to find higher differences between the prices of strippable securities and their portfolios of STRIPS when higher minimum number of bonds are required for stripping.

X2 = Dummy variable as to whether securities are rebundable, 1 (nonrebundable), 0 (rebundable). I expect to find more closeness in prices within the sample of strippable securities that are rebundable.

X3 = the maturity of a bond in years. The descriptions in Livingston and Gregory (1989) shows that as the years to maturity increases, the profits from strippng increases.

Y = the dependent variable. Y is the difference between the prices of the underlying securities and the portfolios of STRIPS:

Y = (UND - PTF)/(PTF), where UND is the price of the underlying security (either ask or bid) and PTF is the price of the portolio of STRIPS (the corresponding ask or bid price).

The differences in the prices between the underlying securities and the portfolio of STRIPS are regressed on the above variables so as to examine their relationship. The results are as follows:

Case involving bid prices:

Y = 0.068009 - 3.8E-05X1 + 0.01073X2 - 0.00402X3
(4.04) (-3.73) (0.81) (-6.10)

Adjusted R-square = 0.0585

Case involving ask prices:

Y = 0.069758 - 3.3E-05X1 + 0.01609X2 - 0.01172X3
(3.83) (-3.06) (1.17) (-16.25)

Adjusted R-square = 0.297

The numbers in parentheses are t-statistics using White's (1980) asymptotically efficient covariance matrix.

The results of the regression analysis show that the coefficient of the minimum number of bonds required is statistically significant. The direction of the coefficient suggests that as the minimum number of bonds required increases, the difference between price of the portfolios of STRIPS and the underlying strippable securities widens, though by a small amount. The coefficient of the dummy variable as to whether the securities are rebundable is insignificant. The coefficient of the years to maturity is statistically

significant showing that as the years to maturity increases, the price of the portfolios of STRIPS becomes increasingly larger than the price of the underlying security. This result is consistent with the descriptions in Livingston and Gregory (1989) that as the years to maturity increases, the profits from stripping becomes larger.

A similar regression on the sample of nonstrippable securities is not done as there do not exist enough data points on the years to maturity or the variable on the ease of stripping the securities (the minimum number of bonds required for stripping).

Summary

The mean differences between the prices of strippable securities and portfolios of STRIPS are significantly different. The prices of the underlying strippable securities market are significantly lower than the prices of the equivalent portfolios of STRIPS. These results are consistent with the descriptions given in Livingston and Gregory (1989) where it is profitable to strip the underlying securities when the term structure is rising. The results of the regression also shows that the price difference is larger as the maturity increases and that is also consistent with the descriptions in Livingston and Gregory (1989).

The differences between the prices of nonstrippable notes and the portfolios of STRIPS are also statistically

significant. There also appear to be significant differences between the bid prices of strippable and nonstrippable notes relative to their equivalent portfolios of STRIPS. However it is not clear why this may be so and this is left for future research.

The variance of the price differences between nonstrippable securities and their equivalent portfolios of STRIPS are higher than the variance of the price differences between strippable securities and their equivalent portfolios of STRIPS. There appears to be higher proportion of arbitrage opportunities involving the nonstrippable notes than involving the strippable notes. This shows that the stripping by the book entry method have brought prices of the strippable securities closer to the prices of their equivalent portfolios of STRIPS and reduced the variability of the price differences between the prices of the underlying strippable securities and their equivalent portfolios of STRIPS.

CHAPTER 3
THE ECONOMIC SIGNIFICANCE OF AUTOCORRELATIONS IN STOCK RETURNS

Background

Much research has been done on the predictability of stock returns. See Poterba and Summers (1988), Fama and French (1988), Conrad and Kaul (1989) and Jegadeesh (1990). Conrad and Kaul (1989) develop a model to obtain estimates of monthly expected stock returns that relies on the rapidly decaying structure of shorter-horizon (weekly) expected returns. The realized returns were characterized by an autoregressive moving average process of order one. Their results show that the expected return estimates they obtained are unbiased predictors of subsequent realized returns and that these expected return estimates explain a substantial percentage of return variances.

Jegadeesh (1990) uses the cross-sectional regressions on lagged returns to provide evidence of predictability of stock returns, also based on an in-sample fit. He further uses his model to obtain forecasts of future returns and based on the predicted returns, portfolios are ranked, with higher ranked portfolios showing abnormal returns larger than lower ranked portfolios.

A motivation for this study is that it is possible that the underlying parameters of those models are not stable over time. The distributions of the returns also may not be stationary over time. In particular, the variance of the returns may vary over subperiods of time. Evidence of autocorrelations in stock returns may not prove to be significantly useful in predicting stock returns and these models may fail to outperform the random walk model out-of-sample. This essay examines the out-of-sample predictive ability of models developed by Conrad and Kaul (1989) and Jegadeesh (1990).

Measuring Out-of-Sample Accuracy

Three statistics are used to measure the out-of-sample accuracy; mean error (ME), mean absolute error (MAE) and root mean square error (RMSE). These statistics were also used by Meese and Rogoff (1983) in their investigation as to whether empirical exchange rate models of the seventies outperform the random walk model of stock prices. These are defined as follows:

$$\text{mean error} = 1/N \sum_{t=1}^{N} [F(t) - A(t)] \qquad (3.1a)$$

$$\text{Mean absolute error} = 1/N \sum_{t=1}^{N} |F(t) - A(t)| \qquad (3.1b)$$

$$\text{root mean square error} = (1/N \sum_{t=1}^{N} [F(t) - A(t)]^2])^{1/2} \qquad (3.1c)$$

$$\text{mean error} = 1/N \sum_{t=1}^{N} [F(t) - A(t)] \qquad (3.1a)$$

$$\text{Mean absolute error} = 1/N \sum_{t=1}^{N} |F(t) - A(t)| \qquad (3.1b)$$

$$\text{root mean square error} = (1/N \sum_{t=1}^{N} [F(t) - A(t)]^2])^{1/2} \qquad (3.1c)$$

where N is the total number of periods in which comparisons are made, F(t) is the forecast value and A(t) is the actual value at time t. The statistics that are more useful are the mean absolute error and the root mean square error. The mean error is reported to examine the overall direction of the errors.

The Random Walk (with Drift) Model of Stock Prices

Before examining models developed by Conrad and Kaul (1989) and Jegadeesh (1990), the random walk with drift model of stock prices is briefly described. In the random walk with drift model, the logarithm of the stock price at time t, P_t, follows the process:

$$P_t = P_{t-1} + \mu + \epsilon_t$$

where

μ is the constant drift term, and

ϵ_t is the error term, iid(0, σ_t).

The model given above is for stock prices. The logarithm of the price relatives is the continuously compounded return for the period from t-1 to t. When the continuously

compounded returns are small in magnitude, the continuously compounded returns are approximately equal to the simple returns. Simple returns are used in this study. The predicted return using the random walk model of stock prices is given by the average or historical mean of the simple returns.

Description of Jegadeesh's (1990) Model

This section describes the methodology used by Jegadeesh (1990) to test for predictability of stock returns. Let R_{it} be the return on security i in month t which is expressed as:

$$R_{it} = E(R_i) + \eta_{it} \tag{3.2}$$

Consider the following cross-sectional regression model:

$$R_{it} = a_{0t} + \sum_{j=1}^{J} a_{jt} R_{it-j} + \nu_{it}.$$

The expression for the slope coefficients in the multivariate regression above is:

$$\begin{bmatrix} a_{1t} \\ \cdot \\ \cdot \\ \cdot \\ a_{Jt} \end{bmatrix} = \left[\text{cov}_i \begin{pmatrix} R_{it-1} \\ \cdot \\ \cdot \\ \cdot \\ R_{it-J} \end{pmatrix} \right]^{-1} \begin{bmatrix} \text{cov}_i(R_{it}, R_{it-1}) \\ \cdot \\ \cdot \\ \cdot \\ \text{cov}_i(R_{it}, R_{it-J}) \end{bmatrix}$$

The subscript under the covariance operator has been included to emphasize that this operation is carried out across the cross-section. Using (3.2) and taking expectations,

$$R_{it} - \bar{R}_i = a_{0t} + \sum_{j=1}^{J} a_{jt} R_{it-j} + \nu_{it},$$

where $\bar{R}$ is an unbiased estimate of the unconditional expected return of security i obtained from a sample period which excludes months $t-J$ through t. Now the covariance between the dependent variable and the jth independent variable is

$$\text{cov}_i(R_{it}-\bar{R}_i, R_{it-j}) = \text{cov}_i(\eta_{it}, \eta_{it-j})$$

The cross-sectional regression model that Jegadeesh (1990) used to present evidence of predictability of stock returns is

$$R_{it} - \bar{R}_{it} = a_{0t} + \sum_{j=1}^{12} a_{jt} R_{it-j} + a_{13t} R_{it-24} + a_{14t} R_{it-36} + \nu_{it}, \quad (3.3)$$

The cross-sectional regression is performed in the following way. At month t, for a full-sample test, all securities in the sample are pooled together (the size-based subsample is adjusted based on market value of equity). The returns at month t for the all the securities are regressed on the lagged returns which in Jegadeesh (1990) model go back as far as 36 months from month t. The coefficients in the cross-sectional regression model are obtained. This window is shifted forward by one month and the process is repeated. In this way, a time-series of regression coefficient estimates are obtained. To obtain the final regression estimates for the in-sample period, Jegadeesh (1990) uses the Fama and MacBeth (1973) method. The final coefficient estimate is the

sectional regression model are obtained. This window is shifted forward by one month and the process is repeated. In this way, a time-series of regression coefficient estimates are obtained. To obtain the final regression estimates for the in-sample period, Jegadeesh (1990) uses the Fama and MacBeth (1973) method. The final coefficient estimate is the mean of the time-series of coefficient estimates obtained, a_{jm}. The t-statistic is given by

$$t(a_{jm}) = a_{jm} * n^{1/2} / s(a_j),$$

where n is the number of cross-sectional regressions, s is the standard deviation of coefficient estimates. Jegadeesh (1990) reports that the serial correlations in the above regression model (3.3) are significantly different from zero. In order to show that higher-ranked portfolios outperform the lower-ranked portfolios (ranking is based on predicted returns), three portfolio strategies are used. For the first strategy, the out-of-sample return forecasts are obtained from the following model:

$$\hat{R}_{it} = \hat{a}_{0t} + \sum_{j=1}^{12} \hat{a}_{jt} R_{it-j} + \hat{a}_{13t} R_{it-24} + \hat{a}_{14t} R_{it-36} \qquad (3.4)$$

where the coefficient estimates in (3.4) are estimated from a regression model similar to the regression model (3.3) but this time the dependent variable is R_{it}.

The estimates in the above regression are obtained as follows. At month t-1 the cross-sectional regression is run for the full sample of securities. The process is repeated

over the period t-60 to t-2. The coefficient estimate over the period t-60 to t-1 is the mean of the time-series of estimates over that period. Having obtained the mean of the coefficient estimates, the subsequent month's return can be predicted based on the above regression in (3.4).

The predicted returns given by (3.4) are then used to rank the securities into ten portfolios. The actual returns of the predictive portfolios are then obtained in the subsequent month. The process is repeated every month with new ranked portfolios formed every month.

The second strategy only considers the predictive ability based on one-month lagged returns, i.e. the only explanatory variable is the one-month lagged returns. The portfolios are formed as above. The third strategy only considers the predictive ability based on twelve-month lagged returns. The securities in the portfolio are each given equal weights. The composition of the securities in Jegadeesh's (1990) vary across months.

The abnormal returns earned by the portfolios formed above are estimated under the market model using the following time series regression:

$$R_{pt} - R_{ft} = \alpha_p + \beta_p(R_{mt}-R_{ft}) + \nu_{pt} \qquad (3.5)$$

The intercept in the (3.5) provides a measure of the abnormal return. The null hypothesis that the abnormal returns are zero is that $\alpha_p = 0$.

Out-of-Sample Test of Jegadeesh's Model (1990)

This subsection attempts to investigate whether the returns predicted by the random walk model can outperform the returns predicted by (3.4)[1]. First, I use the same sample of securities in our study so as to avoid any effects introduction of new securities may have on the portfolio returns in the subsequent months, and to make it possible for the model to be compared with the random walk model. The data for this test ranges from January 1970 through December 1990. I use the CRSP NYSE monthly returns database. The estimation period is 8 years and hence the months for out-of-sample comparison begin from January 1978 through December 1990. The number of securities (same composition) throughout this period is 539. There are no missing values for this sample of 539 securities over the period 1970 through 1990.

The return predicted by the random walk model for period t is the mean of the past 96 monthly returns. With rolling regressions as done by Jegadeesh (1990), the returns given by the random walk model change accordingly from one period to another.

Jegadeesh (1990) rank portfolios based on the forecast returns obtained from (3.4) and show that the higher ranked portfolios show larger abnormal returns than lower ranked

[1] Notice that eq. (3) is not suitable for predictive purposes because it contains the mean monthly return of security i in the sample period that goes beyond the predicted month.

portfolios. However to control for the possibility that ranking based on the returns as predicted by the random walk model may likewise show similar results, the procedures will be repeated with ranking based on the corresponding returns given by the random walk with drift model. I will examine whether higher ranked portfolios based on the historical mean returns likewise perform better than lower ranked portfolios out-of-sample.

To examine whether investors can gain abnormal returns using this strategy, I subtract the transaction costs from the monthly holding returns and use these monthly returns (after transaction costs) in regression (3.5). The transaction costs are obtained by looking at the change in the composition of the securities from month to month in the top and bottom ranked portfolios.

In a recent article, Kaul and Nimalendran (1990) show, using the variance-ratio test, that bid-ask errors in transaction prices are the apparent source of negative autocorrelation in security returns. Roll (1984) has shown that if the bid-ask errors in transaction prices are independently distributed over time, they will induce negative autocorrelation in observed returns only at lag 1. However if bid-ask errors are not independent over time, they can induce autocorrelations beyond lag 1, resulting in higher-order moving-average process of returns.

Using bid-bid returns in their variance-ratio tests, Kaul and Nimalendran (1990) show that security returns are positively autocorrelated and not negatively autocorrelated. I likewise use bid-bid returns and the transaction returns to estimate the coefficients of the one-month lagged return in Jegadeesh's model (1990). I use the daily Nasdaq National Market System (NMS) files which contain bid-ask price quotations. Only those securities with less than 25 missing daily returns over this period are included to ensure that the monthly returns computations are done with minimal errors.[2] The same composition of securities (546 securities altogether) is used for the period beginning January 1985 through December 1990.

I use only one-month lagged returns because of the lack of the period to estimate Jegadeesh's model up to the thirty-sixth lagged monthly return. The mean of 24 historical coefficient estimates is used in deriving the predicted returns. The abnormal returns from the portfolios using bid-bid returns to estimate the coefficients of the model are compared to the abnormal returns using transaction returns to estimate the model.

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[2] Owing to data source limitations, no bid-ask data are available for all securities in February 1986, and this already accounts for 19 missing daily returns.

Description of the Model Developed by Conrad and Kaul (1989)

This section examines the model developed by Conrad and Kaul (1989) which will be later used for out-of-sample tests. Conrad and Kaul (1988) propose a (arbitrary) first-order autoregressive process for weekly expected returns:[3]

$$R^w_t = E_{t-1}(R^w_t) + e^w_t \tag{3.6}$$

$$E_{t-1}(R^w_t) = \phi E_{t-2}(R^w_{t-1}) + u_{t-1} \tag{3.7}$$

where

R^w_t = the continuouly compounded returns on a security for week t,

$E_{t-j}R(^w_{t-j})$ = the expected return on the security for week t-j+1 formed at the end of week t-j.

$e^w_t \sim$ iid $N(0, \sigma^2_e)$

$u^w_t \sim$ iid $N(0, \sigma^2_u)$

and $0 < \phi < 1$.

Equation (3.6) is substituted in (3.7) and the realized returns are expressed as

$$R^w_t = \phi R^w_{t-1} + e^w_t - \theta e^w_{t-1} + u^w_{t-1} \tag{3.8}$$

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[3] Recent asset pricing models, such as Merton's intertemporal model (1973), do not require time-invariant expected return. Expected returns can be time-varying in asset pricing models and market efficiency can still hold.

(3.8) implies that the realized returns can be characterized by an ARMA (1,1)[4] process of the form

$$R^w_t = \phi R^w_{t-1} + a^w_t - \theta a^w_{t-1} \qquad (3.9)$$

Conrad and Kaul (1988) show that the expected returns are well characterized by a stationary autoregressive process, estimates of ϕ are between 0.65 and 0.4 . Using equation (3.7) and equation (3.9), they express the conditional expected return for a particular month in terms of past weekly realized returns:

$$E_{t-4}(R^m_t) = \pi_1 R^w_{t-4} + \pi_2 R^w_{t-5} + \pi_3 R^w_{t-6} + \ldots \qquad (3.10)$$

where

$$\pi_i = \theta^{i-1}(\phi - \theta)(1 + \phi + \phi^2 + \phi^3) \qquad i = 1, 2, 3 \ldots$$

As the values of ϕ and θ are between 0 and 1, it follows that the values of π_i or the weights attached to past returns rapidly decay the further back the historical returns. According to Conrad and Kaul, Equation (3.10) suggests that estimating expected returns using past weekly returns is preferred to the use of historical monthly returns as the use

[4] ARMA stands for autoregressive moving average process. (1,1) denotes that the returns process, R_t, is a first-order autoregressive processes and the error term, e_t, is a first-order moving average process.

of historical monthly returns put equal weights on the weekly returns within the particular month.[5]

To examine the impact of firm size on the predictability of returns, stocks are sorted into 5 portfolios based on the market values of the equity. The excess weekly returns for a portfolio is obtained by subtracting the return on a one-week Treasury from the portfolio returns.

Conrad and Kaul (1989) find that the autocorrelation coefficients of a certain order is largest for the daily portfolio returns, as compared to weekly and monthly portfolio returns. For daily, weekly and monthly returns, as firm size increases the autocorrelation coefficient decreases, implying there is a impact of size on the autocorrelation coefficients obtained. For daily and weekly returns, higher order autocorrelations remain significant for all but the largest portfolio (which exhibits first-order autocorrelation only). For monthly returns, autocorrelations are significant only at the first lag and the largest portfolio (which has very low autocorrelation of the first-order) behaves like white noise.

To examine whether the high autocorrelation reported could be due to infrequent trading, Conrad and Kaul replicate the tests for autocorrelations but excluding all securities

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[5] Weekly returns rather than daily returns are used by Conrad and Kaul (1988) to estimate the monthly expected returns as daily data have potential biases associated with infrequent trading, the bid-ask effect, etc.

that do not trade on the first and last days of the week. Their results are virtually the same as before.

To examine for the January effect, the model in equation (3.9) is modified as

$$R^w_t = \delta_o + \delta_i + \phi R^w_{t-1} + a^w_t - \theta a^w_{t-1} \qquad (3.11)$$

where $\delta_i = 1$ if ith week of January, 0 otherwise. They use the Kalman filter and the Marquardt maximum-likelihood procedure proposed by Ansley (1980) to obtain the parameters in Equation (11). The estimates of ϕ are significantly different from both zero and less than one for all portfolios. The estimates of ϕ and θ which are all less than 0.7 and 0.5 respectively imply rapidly decaying time variation in weekly expected returns.

Out-of-Sample Tests of the Model by Conrad and Kaul (1989)

This out-of-sample test examines the forecasting accuracy of the model in (3.9) (without the January effect) relative to the random walk model. Conrad and Kaul use a total sample size of 1226 weekly returns (Aug 1962 to Dec 1985) to obtain estimates of the parameters in (3.9). The securities in their portfolios are value-weighted. Stocks are sorted into size-based portfolios at the end of each year. In the following year, one-week returns are calculated for each security. New

securities listed on the NYSE and AMEX are included in their sample from time to time as they are listed.

In this study, I use the same set or composition of securities throughout the entire sample period. The use of the same composition of securities is motivated by the fact that the model is expected to predict (if it does so significantly) for the returns of subsequent month the returns of the same portfolio. The same composition of securities in the size-based portfolios are formed in the following way. At the end of years 1962 through 1990, the market values (price multiplied by outstanding number of shares) of the securities are obtained and securities are ranked based on the average of the market values. It may appear that the formation of these portfolios is done with good foresight, i.e. the same composition of securities throughout our study beginning in August of 1962 as if the future composition of the securities is already known. This portfolio formation method should not be a problem as we are trying to examine ex-post the predictive ability of the model for different size-based portfolios.

The securities in this study are equally-weighted. The the same sample interval of 1226 weeks is used and the window (of 1226-week length) is shifted by 1 week forward. Hence the estimates are updated every week. The predicted return for the following week is given by (3.9). I use the nonlinear procedure of Box and Jenkins (1970, chap. 7). The returns

predicted by the random walk model are the means of the historical returns. The predicted return from (3.9) is compared with the actual return of the following week and contrasted with the forecasts given by the random walk model.

Results

Jegadeesh's (1990) model vs. the Random Walk Model

Table 3-1 reports the results on the predictive ability of Jegadeesh's model and the random walk model. The mean absolute error and the root mean square error given by Jegadeesh's model appear not to be appreciably different from the random walk with drift model. Table 3-2 reports the performance of the predicted portfolios based on the market model for the period from January 1979 through December 1990. The equally weighted market index is used. The results show that portfolios formed based on Jegadeesh's cross-sectional model and one-month lagged returns exhibit abnormal returns, with portfolio P1 showing the highest abnormal return and P10 showing the lowest abnormal return. Portfolios formed based on the random walk model, do not exhibit abnormal returns except for portfolio P5.

The top portfolio formed in this study based on the predicted return using Jegadeesh's model does not exhibit abnormal returns at the same magnitude in Jegadeesh (1990). The excess returns before transaction costs is 0.67% for portfolio P1 in this study but it is 1.1% in Jegadeesh (1990).

All these excess returns for the long investment strategies, however, are wiped out after considering transactions costs for portfolio rebalancing (see Table 3-3). A two-way (buy and sell) transaction costs of 0.5% is used for this purpose. Using the zero-investment strategy, i.e., shortselling portfolio P10 and buying portfolio P1, the mean of the returns obtained is 0.96%, after taking into account the transaction costs. However there is no arbitrage as there were 60 negative monthly realized returns out of 156 monthly holding periods. Owing to some institutional restrictions, such as the uptick rule, the zero-investment strategy cannot be carried out without encountering some problems in executing the orders.

To examine whether the higher excess returns in Jegadeesh (1990) may be due to the introduction of new securities and delisting of securities, I repeat the same procedure but this time, as new securities are listed, they are included as what Jegadeesh (1990) did. The excess returns exhibited by the portfolios are not very much different from the sample with the same composition of securities (see Table 3-4). Also, after transaction costs, the long investment strategies do not exhibit abnormal returns (see Table 3-5). This suggests that the abnormal returns one obtains may be dependent on the period of the study. Using the zero-investment strategy, the mean monthly returns is 1.19% after transaction costs. Again there is no arbitrage from this strategy as there are 56

negative monthly realized returns. This study shows that the predictive ability of Jegadeesh's cross-sectional autogressive model does not appreciably outperform the random walk with drift model and that an investor cannot gain from the long investment strategy after accounting for transaction costs.

The results using bid-bid returns and transaction returns to estimate the coefficients are given in Table 3-6. The results are striking. Table 3-6 shows that the portfolio P1 formed based on predicted returns using bib-bid returns shows no abnormal returns, in contrast to portfolio P1 formed based on transaction returns. The negative excess returns in P10 using the bid-bid returns are of a smaller magnitude than the portfolio P10 formed using transaction returns. This shows that bid-ask errors in transaction prices do affect the autocorrelation in stock returns and account for a large portion of the abnormal returns for the portfolio P1. The results in this study show that using bid-bid returns, stock returns are less negatively correlated.

ARMA (1,1) vs. the Random Walk with Drift Model of Stock Prices

Table 3-7 shows that the ARMA (1,1) model of stock returns for the smallest quintile portfolio does not appreciably outperform the random walk with drift model of stock prices out-of-sample. The root mean square error statistics are very close to each other. The mean absolute error when the random walk model of stock prices is used to

predict the returns is smaller in magnitude than the mean absolute error using the ARMA (1,1) model. The out-of-sample analysis for the other quintiles of larger market values is not repeated as they are not expected to perform better than the smallest quintile portfolio.

Summary

This essay shows that the cross-sectional autoregressive model does not appreciably outperform the random walk model out-of-sample. An investor is not expected to gain abnormal returns after accounting for transaction costs by following the investment strategy implied by the cross-sectional autoregressive model. It is shown that much of the abnormal returns from the cross-sectional autoregressive model can be accounted for by bid-ask errors in transaction prices. The autoregressive moving average model of stock returns also does not appreciably outperform the random walk model of stock prices.

TABLE 3-1
PREDICTIVE ABILITY OF JEGADEESH'S MODEL AND THE RANDOM WALK WITH DRIFT MODEL: 1970-1990 dataset

	ME	MAE	RMSE
J36	0.000002	0.067005	0.093797
J1	0.001199	0.067182	0.093855
RWD (96)	0.000750	0.067335	0.094022

Notations:
ME : mean error
MAE : mean absolute error
RMSE : root mean square error
J36 : Jegadeesh's model up to the 36th lag.
J1 : Jegadeesh's model up to the 1st lag.
RWD (96): random walk model using mean of past 96 monthly returns to predict subsequent month's return.

Note:

The returns for deriving the statistics listed above must be multiplied by 100 to obtain values in percentage terms.

TABLE 3-2

THE PERFORMANCE OF THE PREDICTED PORTFOLIOS (BEFORE TRANSACTION COSTS) BASED ON THE MARKET MODEL (JENSEN'S MEASURE OF EXCESS RETURNS OR α (IN %)) USING THE SAME COMPOSITION OF SECURITIES FOR THE PERIOD OF JANUARY 1978 THROUGH DECEMBER 1990

A. Jegadeesh's autoregressive model, including the 36-month lagged return.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
α	0.64	0.48	0.32	0.37	0.20	0.12	0.12	-0.19	-0.37	-1.01
Wt	3.6*	3.1*	2.4*	2.9*	1.6	0.9	0.9	-1.3	-2.5*	-5.1*

B. Jegadeesh's autoregressive model (based on one-month lagged return).

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
α	0.35	0.38	0.27	0.23	0.281	0.10	0.11	0.02	0.25	0.81
Wt	1.76*	2.57*	1.83*	1.72*	2.11*	0.74	0.87	0.13	-1.51	-3.90*

C. Jegadeesh's autoregressive model (based on twelve-month lagged return).

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
α	0.22	0.17	0.144	0.13	0.129	0.1338	0.16	0.10	-0.07	-0.42
Wt	1.21	1.10	1.04	1.02	1.13	1.00	1.28	0.68	-0.45	-2.20

TABLE 3-2--continued

D. Random walk with drift model (using the mean of 96 monthly returns to predict)

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
α	0.04	-0.04	-0.01	0.07	0.28	0.12	0.20	0.16	0.03	-0.17
Wt	0.26	-0.32	-0.10	0.55	2.03*	0.86	1.37	1.01	0.21	-0.73

* significant at least at the 5% level.

Note:

P1-P10 denotes the ten portfolios formed based on either the mean return or the predicted return using the cross-sectional autoregressive model. For eg., for portfolios formed based on the mean return (random walk with drift), P1 is the portfolio formed based on the highest mean return. The portfolio formed based on the highest predicted return using the cross-sectional autoregressive model falls under P1. Wt denotes White's t-statistics which are calculated using the heteroskedasticity-consistent estimates of the standard errors suggested by White (1980).

TABLE 3-3
THE PERFORMANCE OF THE PREDICTED PORTFOLIOS (AFTER TRANSACTION COSTS) BASED ON THE MARKET MODEL (JENSEN'S MEASURE OF EXCESS RETURNS OR α, (IN %)) USING THE SAME COMPOSITION OF SECURITIES FOR THE PERIOD OF JANUARY 1978 THROUGH NOVEMBER 1990

	P1
α	0.24
Wt	1.40

Note:

P1 is the portfolio formed based on the highest predicted return using the cross-sectional autoregressive model. Wt denotes White's t-statistics which are calculated using the heteroskedasticity-consistent estimates of the standard errors suggested by White (1980).

TABLE 3-4
THE PERFORMANCE OF THE PREDICTED PORTOLIOS (BEFORE TRANSACTION COSTS) BASED ON THE MARKET MODEL (JENSEN'S MEASURE OF EXCESS RETURNS OR α (IN %)) USING SECURITIES AS THEY ARE LISTED FOR THE PERIOD OF JANUARY 1978 THROUGH DECEMBER 1990

Jegadeesh's autogressive model (including the 36-month lagged return)

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
α	0.57	0.58	0.54	0.40	0.09	0.14	0.060	-0.12	-0.46	-1.39
Wt	3.74*	4.68*	5.11*	4.29*	1.09	1.24	0.60	-1.22	-3.80*	-8.74*

* significant at least at the 5% level.

Note:

P1-P10 denotes the ten portfolios formed based on the predicted return using the cross-sectional autoregressive model. P1 is the portfolio formed based on the highest predicted return. Wt denotes White's t-statistics which are calculated using the heteroskedasticity-consistent estimates of the standard errors suggested by White (1980).

TABLE 3-5
THE PERFORMANCE OF THE PREDICTED PORTOLIOS (AFTER TRANSACTION COSTS) BASED ON THE MARKET MODEL JENSEN'S MEASURE OF EXCESS RETURNS OR α (IN %) USING SECURITIES AS THEY ARE LISTED FOR THE PERIOD OF JANUARY 1978 THROUGH NOVEMBER 1990

	P1
α	0.08
Wt	0.55

Note:

P1 is the portfolio formed based on the highest predicted return using the cross-sectional autoregressive model. Wt denotes White's t-statistics which are calculated using the heteroskedasticity-consistent estimates of the standard errors suggested by White (1980).

TABLE 3-6

THE PERFORMANCE OF THE PREDICTED PORTOLIOS (BEFORE TRANSACTION COSTS) BASED ON THE MARKET MODEL (JENSEN'S MEASURE OF EXCESS RETURNS OR α (IN %)) USING SECURITIES TRADED ON NASDAQ FOR THE PERIOD FROM MAY 1987 THROUGH DECEMBER 1990

A. Jegadeesh's autoregressive model using bid-bid returns to get coefficient estimates of one-month lagged return.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
α	0.65	-0.03	0.05	0.08	-0.16	-0.25	-0.05	-0.24	-0.59	-1.74
Wt	1.20	-0.08	0.16	0.29	-0.58	-0.87	-0.15	-0.80	-1.58	-3.38

B. Jegadeesh's autoregressive model using transaction returns to get coefficient estimates of one-month lagged return.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
α	1.13	0.47	0.002	0.05	-0.08	-0.34	-0.05	-0.17	-1.17	-2.16
Wt	2.11*	1.23	0.006	0.18	-0.30	-1.16	-0.18	-0.63	-3.22*	-4.36*

* significant at least at the 5% level.

Note:

P1-P10 denotes the ten portfolios formed based on the predicted return using the cross-sectional autoregressive model. P1 is the portfolio formed based on the highest predicted return. Wt denotes White's t-statistics which are calculated using the heteroskedasticity-consistent estimates of the standard errors suggested by White (1980).

TABLE 3-7
PREDICTIVE ABILITY OF ARMA (1,1) MODEL OF STOCK RETURNS AND THE RANDOM WALK WITH DRIFT MODEL OF STOCK PRICES: 1986-1990

Smallest-sized based portfolio

	ME	MAE	RMSE
ARMA (1,1)	0.00188	0.01444	0.02355
RWD	-0.0031	0.014259	0.02387

Notations:
ME : mean error
MAE : mean absolute error
RMSE : root mean square error
ARMA (1,1): autoregressive moving average model of order 1,1.
RWD : random walk model using mean of past 1226 weekly returns to predict subsequent week's return.

Note:
The returns for deriving the above statistics must be multiplied by 100 to get the values in percentage terms.

CHAPTER 4
INTERNATIONAL DIVERSIFICATION OF INVESTMENT PORTFOLIOS: MULTI-COUNTRY PERSPECTIVES

Background

The gains from international diversification of investment portfolios have been examined by various researchers such as Grubel (1968), Levy and Sarnat (1970), Solnik (1974) and Lessard (1976). The studies by these researchers use returns series in an era where exchange rates were mainly fixed. The low correlations among asset returns from the various countries contribute substantially to the gains from international diversification. Since March 1973, the floating exchange rate system was adopted.[1] Exchange rate risk is a crucial factor for investors who wishes to invest overseas. It is important to study whether exchange rate risk can make it unattractive to hold an internationally diversified portfolio and whether hedging this risk is worthwhile.

In a recent working paper, Levy and Lim (1991) analyze the gains from hedging and not hedging international bond

[1] The volatility of exchange rates since then has been documented by Huang (1981), among others. Huang shows that exchange rates are too volatile to be consistent with the monetary model and/or rational expectations.

portfolios, taking into consideration that the forward rate is a biased predictor of the future spot rate. In an earlier paper, Eun and Resnick (1988) assume that the forward rate is a nearly unbiased predictor of the future spot rate and focus on the risk side. However, Levy and Lim (1991) focus both on risk and return. They show that the unhedged portfolios outperformed the hedged portfolios between 1985 and 1988, when the forward rates underestimated the rate of depreciation of the U.S. dollar, due to the higher mean returns from the unhedged portfolios. The hedged portfolios outperformed the unhedged portfolios between 1981 and 1984 when the forward rates underestimated the rate of appreciation of the U.S. dollar. In this essay, I examine to what extent the bias in the forward rates affect the performance of the hedged and unhedged stock portfolios from the perspectives of investors from different countries. Also, I analyze who gains the most from international diversification among investors from Canada, France, Germany, Japan, Switzerland, United Kingdom and U.S.A.

Hedging affects the portfolio mean and returns. In a recent paper, Black (1990) demonstrates that for a given distribution of exchange rates between, say, the German marks and the U.S. dollar, both the German and the American investors increase their respective portfolio mean returns by

not hedging some part of their portfolio. Hence a partial hedge may prove to be an optimal policy.[2]

Eun and Resnick (1988) have shown that between 1980 and 1985, exchange rate volatility accounted for about fifty percent of the volatility of the dollar returns from investments in the stock markets of countries such as Germany, Japan and the U.K. At issue then is whether an investor who hedges exchange rate risk via the interbank forward market for foreign exchange can reap further gains from international diversification of investment portfolios, as compared to an unhedged strategy.

Eun and Resnick (1988) show that the ex-ante investment strategies based on the minimum variance portfolio (MV), equally weighted portfolio (EQ), the tangency portfolio (TG) and the Bayes-Stein investment (BS) strategies that incorporate hedging via the forward markets consistently outperform the corresponding ex-ante investment strategies that are unhedged. They use stock market returns data and their overlapping out-of-sample holding periods cover the interval between the first week of 1983 and the end of 1985.

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[2] The example is as follows: Suppose that the current exchange rate is 1 DM/US$. One period hence, the distribution is 2DM/US$ with probability 1/2 and 0.5 DM/US$ with probability 1/2. A riskless asset in the U.S. pays 1 US$ and a riskless asset in Germany pays 1 DM. The expected excess return (over the risk-free rate) of holding the foreign asset and not hedging the exchange risk is 25 % for both investors. See Black (1990).

The motivations for examining the performance of the unhedged and hedged portfolios for the two periods from January 1981 to December 1984 and from January 1985 to December 1988 are

1) Recent empirical evidence from studies by Fama (1984) and Frankel and Froot (1989) has shown that the forward rates are biased predictors of the future spot rates.[3] The direction of bias in the forward rates would affect the hedged portfolio mean returns and hence the relative performances of the hedged and unhedged strategies.[4]

2) Levy and Lim (1991) find that the forward rates on the average underestimated the rate of depreciation and also the rate of appreciation of the U.S. dollar from early 1981 through Dec 1988 and this essay attempts to analyze the extent the forward exchange bias has from the perspectives of investors from different countries.

Between early 1981 and late 1984, the U.S. dollar, on the average, appreciated against major currencies such as Japanese

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[3] I do no attempt in this essay to analyse the source of the bias. Conditional on the hypothesis that the forward exchange market is efficient or rational, Fama (1984) attributes the bias to time-varying risk premium while Froot and Frankel (1989) cannot reject the hypothesis that all of the bias is attributable to systematic expectational errors, and they reject the hypothesis that all of the bias is due to the risk premium.

[4] The direction of bias in this essay refers to some systematic way the forward rates deviate from the actual spot rates.

yen, UK pounds, German marks, French francs and Swiss francs. If the forward rates on the average underestimate the rate of appreciation of the U.S. dollar, the U.S. investor would have increased his US$ adjusted mean returns at a lesser variance if he had hedged via the forward market.

Between early 1985 and December 1988, the U.S. dollar depreciated against other major currencies. If the forward rates on the average underestimate the rate of depreciation of the U.S. dollar, the U.S. investor may find that it is more desirable not to hedge in the foreign exchange forward market, as the mean returns from an unhedged strategy would be higher than the mean returns from a hedged strategy.

Exchange Rate Volatility and the Forward Market Hedge

Unhedged strategies

Much of the analysis here on getting unhedged, partially hedged and hedged returns is done with reference to an investor from the U.S.A. Similar calculations when applied would also hold for investors from other countries. The dollar rate of return, R_i, from an unhedged investment in the foreign market is

$$R_{i\$} = (1+R_i)(1+e_i) - 1 \quad (4.1a)$$

$$R_{i\$} = R_i + e_i + R_i e_i, \quad (4.1b)$$

R_i is the random local currency rate of return, e_i is the rate of appreciation of the local currency against the U.S. dollar. Since $R_i e_i$ is small,

$$R_{i\$} \approx R_i + e_i \tag{4.2}$$

The variance of the dollar rate of return of the ith asset can be approximated as

$$Var(R_{i\$}) \approx var(R_i) + var(e_i) + 2cov(R_i, e_i) \tag{4.3}$$

The variance of the portfolio returns, $var(R_{p\$})$ can be written as:

$$Var(R_{p\$}) = \Sigma_i X_i^2 var(R_{i\$}) + \Sigma_i \Sigma_{j \neq i} X_i X_j cov(R_{i\$}, R_{j\$}), \tag{4.4}$$

where X_i is the weight allocated to the ith asset.

Employing eq. (4.2), we have,

$cov(R_{i\$}, R_{\$j}) \approx cov(R_i, R_j) + cov(e_i, e_j) + cov(R_i, e_j) + cov(R_j, e_i)$.

Therefore, employing eqs. (4.3) and (4.4), $var(R_{p\$})$ is approximated as,[5]

$$Var(R_{p\$}) \approx \Sigma_i \Sigma_j X_i X_j cov(R_i, R_j) + \Sigma_i \Sigma_j X_i X_j cov(e_i, e_j) + 2\Sigma_i \Sigma_j X_i X_j cov(R_i, e_j). \tag{4.5}$$

The second and third terms on the right of eq. (4.5) further contribute to the overall portfolio variance if they are positive.

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[5] Note that in eq. (4.5), we do not impose the constraint $i \neq j$, hence each term includes variances as well as covariances.

100 % Hedged Strategies

In a hedged strategy, the investor sells foreign currency forward for US$. Assuming that the investor hedges 100 % of the initial investment and expected return, the certain dollar return is:

$$(1+E(R_i))(1+f_i) - 1. \tag{4.6}$$

The realized local currency return may be different from the mean, giving rise to the uncertain element that is not hedged, $(R_i - E(R_i))$. Therefore, the 100 % hedged dollar return is:

$$R_{i\$}^{H} = (R_i - E(R_i))(1+e_i) + (1+E(R_i))(1+f_i) - 1. \tag{4.7a}$$

$$R_{i\$}^{H} = R_i + f_i + R_i e_i + E(R_i)(f_i - e_i). \tag{4.7b}$$

Because the third and fourth terms are small, $R_{i\$}^{H}$ can be approximated by

$$R_{i\$}^{H} \approx R_i + f_i \tag{4.8}$$

The variance of a 100 % hedged international portfolio is given by

$$Var(R_{p\$}^{H}) \approx \Sigma_i \Sigma_j X_i X_j \, cov(R_i, R_j) \tag{4.9}$$

Partial Hedge Strategies

In a partial hedge strategy, the investor hedges part of his initial investment and expected return in the foreign markets. Say the percentage of the initial investment hedged is w. Then the partially hedged dollar return is

$$R_{i\$}^{wH} = [(1+R_i) - w(1+E(R_i))](1+e_i) + w(1+E(R_i))(1+f_i) - 1. \tag{4.10}$$

where the superscript wH denotes the partial hedge strategy. $R_{i\$}^{wH}$ can be approximated as

$$R_{i\$}^{wH} \approx R_i + e_i + w(f_i - e_i) \quad (4.11)$$

This essay later examines whether there is a partial hedged strategy that may be superior to the unhedged strategy or the 100 % hedging strategy.

It is possible that partial or zero hedging may decrease the portfolio variance relative to 100% hedging. For example, if e_i and R_j are negatively correlated, the 100% hedged portfolio may have a larger variance relative to the zero or partial hedged portfolio. Note that if the forward rate is biased such that it is lower or higher than the future spot rate, hedging will affect the portfolio mean. The final effect on the investor's welfare is not clear. This essay further contributes to the understanding of hedging international portfolios by looking at it from the perspectives of investors from different countries.

The Bayes-Stein Portfolio Strategy

Eun and Resnick (1988) look at the intertemporal stability of the tangency portfolio and the minimum-variance portfolio of stocks for various countries. They find that the weights allocated to each country are highly variable with time if the tangency portfolio investment strategy is used to calculate the weights. This was not so when the minimum variance portfolio investment strategy is used to calculate

the weights. This demonstrates that the minimum variance portfolio is relatively more stable.

Jorion (1985) points out that the intertemporal instability of the tangency portfolio weights is mainly due to the intertemporal instability of the mean-return vector. The minimum-variance portfolio investment strategy does not depend on the mean-return vector as input. Since the variance-covariance matrix is stable over time, the investment weights of the portfolio are also stable. Thus, the important issue then in constructing ex-ante portfolio strategies is to estimate more accurately the mean-return vector. Jorion (1985, 1986) has formulated a Bayes-Stein approach for estimating the ex-ante expected return vector in solving the portfolio problem. Let us elaborate on the Bayes-Stein shrinkage estimation method that we shall employ in the empirical section.

In deriving the optimal investment weights in general, the ex-post means and variance-covariance matrix are employed. The Bayes-Stein method adjusts these ex-post parameter estimates as follows:

The conditional expected return vector, $\underline{R}$ is given by

$$\underline{R} = (1-d)\underline{Y} + d\underline{1}Y_o \qquad (4.12)$$

where

a bar denotes a vector,

$\underline{Y}$ is the N X 1 ex-post sample mean-return vector of the N assets,

$\underline{1}$ is the vector of ones,

Y_o denotes the mean return from the ex-post minimum-variance portfolio,

d represents estimated shrinkage factor for shrinking the elements of $\underline{Y}$ toward Y_o. d is given by

$$d = \frac{(N+2)(T-1)}{(N+2)(T-1) + (\underline{Y}-Y_o\underline{1})'TS^{-1}(T-N-2)(\underline{Y}-Y_o\underline{1})}, \quad (4.13)$$

where

T represents the length of the time series of the sample observations,

S is the usual N X N sample variance-covariance matrix.

As the sample variance-covariance matrix is stable through time, the conventional unbiased estimate for the inverse of the true variance-covariance matrix is given by

$$\Sigma^{-1} = \frac{(T-2-N)}{(T-1)} S^{-1} \quad (4.14)$$

(see Jobson and Korkie, 1980). The Bayes-Stein method solves for the optimal ex ante Bayes-Stein tangency portfolio using equation (4.12) for the expected return vector and equation (4.14) for the inverse of the variance-covariance matrix. The Bayes-Stein expected return vector in (4.12) is used in place of the usual sample mean of returns and applied to the usual tangency portfolio strategy.

Data and Methodology

I employ ex-post data to find the investment weights and then use these weights for an ex-ante investment. This study uses Morgan Stanley stock returns data from seven countries, the U.S., Japan, West Germany, France, Switzerland, Canada and Great Britain. The risk-free rates for the investor from U.S. is obtained from the Fama files in the CRSP bond database. As for the risk-free rates for investors from the other countries, the equivalent Treasury bill rates of these countries are obtained from the International Financial Statistics database. When Treasury bill rates are not available, the rate that is used is (1.1 X discount rate). The inflation indices are obtained from International Financial Statistics.

The four ex-ante investment strategies that will be used in this study are the hedged equally weighted portfolio strategies (EQ), minimum variance portfolio strategies (MV), tangency portfolio strategies (TG), the Bayes-Stein method (BS) and their unhedged and partially hedged counterparts. We report the performance results of these strategies for 30-day holding periods with no short sales.

The length of the time series of sample observations (or the estimation interval) for the purpose of estimating the portfolio weights is 3 years for 30-day holding periods. To get the holding period return of the subsequent month, the estimation interval is moved up one month and the process is

repeated. For example, the first estimation interval for the 30-day holding period begins in January 1978 and ends in December 1980. The portfolio weights (for the MV, TG and BS strategies) obtained from this estimation interval are applied to the holding period of January 1981 to obtain the out-of-sample returns for January 1981. The second estimation interval begins in February 1978 and ends in January 1981 and the process is repeated. There are 96 non-overlapping out-of-sample monthly holding periods between January 1981 and December 1988. For the tangency portfolio and Bayes-Stein portfolio strategies, the asset proportions or weights that are applied to the holding period of the subsequent month are obtained at the point of tangency or the optimal unlevered portfolio (However, the weights will be different since the Bayes-Stein method adjusts the ex-post parameters). The risk-free rates used for estimating the asset weights for the TG and BS strategies are those that exist in the corresponding 30-day holding periods. For strategies that use the forward hedge, the 30-day forward rates are obtained from the Wall Street Journal on the first day of each 1-month holding period.

The mean of the holding period returns, $E(R_p)$ and their standard deviations, σ_p are calculated. The performance of the various strategies is then compared using the Sharpe measure of portfolio performance (SHP). The risk-free rate, r_f that is used for the SHP is the mean of the risk-free rates

corresponding to the holding periods. The SHP is $(E(R_p - r_f)/\sigma_p)$.

I also analyze who gains the most from international diversification among this group of investors from seven countries using stochastic dominance, and based on real returns. The real ex-post portfolio returns are obtained by adjusting the nominal rates of returns by the inflation rates. The investment strategies that are analysed are the unhedged and 100% hedged strategies from the perspectives of the investors from the seven countries, and the out-of-sample monthly real returns are from January 1981 through December 1989.

Results

Relative Performance Using the Sharpe Performance Index (SHP)

Tables 4-1 through 4-7 present the means and standard deviations for hedged and unhedged specific-currency adjusted stock returns of the various countries. The results show that the mean returns of the hedged portfolios are higher than the mean returns of the unhedged international portfolios for the period 1981-84 but the reverses in the period 1985-88, for the U.S. and Canadian investors. The mean returns of the unhedged and hedged international portfolios do not show such variability for the French investor. The mean returns of the naive EW portfolio strategy for the German investor show some

declining trend as the hedging proportion is increased for the period 1981-84 but not for the other investment strategies. There is not much change in the mean returns as the hedging proprotion is increased for the period 1985-88.

As for the Japanese investor, there is not much change in the means as the hedging proportion is increased for the period 1981-84 but the mean returns show some increasing trend for the naive EQ method. The other investment strategies do not show much changes for this period. There is not much changes for the period 1985-88.

As for the Swiss investor, the mean returns show a declining trend for the naive EQ strategy as the hedging proportion is increased but not for the other investment strategies. The mean returns for the German investor do not show such variability as for the U.S. and Canadian investors for the period 1985-88.

As for the UK investor, the mean returns for the unhedged portfolio show a declining trend for the period 1981-84 as the hedging proportion is increased for the EW strategy, but not at the same magnitude as for the U.S. and Canadian investors. The other investment strategies do not show such variability. For the period 1985-88, the EW strategy shows an increasing trend as the hedging proportion is increased. This is not so for the other investment strategies.

In all the strategies and from the perspectives of the investors from the seven countries, the mean returns do not

change substantially for the period 1981-88. These statistics show that the biasedness of the forward rates in different periods affect the mean portfolio returns of the hedged and unhedged strategies, particularly for the U.S. and Canadian investors. The biasedness test (not reported) using the mean of (ln(F)-ln(S1)), where F is the forward rate and S1, the future spot rate, shows that the forward rates are biased estimators of future spot rates against most currencies from the perspectives of investors from the U.S. and Canada, but the forward rates are biased estimators of future spot rates against much fewer number of currencies from the perspectives of investors from other countries. Consistent with the biasedness test results, the mean portfolio returns of the hedged and unhedged strategies are not very much different from each other for most investment strategies from the perspectives of investors from countries other than the U.S. and Canada.

Determining Who Gains the Most from International Diversification

Using stochastic dominance as performance measures in determining the investor who gains the most from international diversification for the period 1981-89, I find out that no investor dominates another using First Degree Stochastic Dominance (FSD). Using Second Degree Stochastic Dominance (SSD), it is found out that there is no single investor from

TABLE 4-1
PERFORMANCE OF INTERNATIONAL STOCK PORTFOLIOS: U.S. POINT OF VIEW

A.

Period: 1981-1984		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	-0.280	-0.091	0.099	0.288	0.478	0.667
	Std	3.989	3.741	3.528	3.356	3.233	3.164
	SHP	-0.070	-0.024	0.028	0.086	0.148	0.211
MV	M-rf	-0.049	0.070	0.256	0.517	0.826	1.139
	Std	3.872	3.737	3.582	3.414	3.195	3.058
	SHP	-0.013	0.019	0.072	0.152	0.258	0.372
TG	M-rf	-0.677	-0.509	-0.197	0.136	0.484	0.885
	Std	4.964	4.665	4.113	3.791	3.556	3.507
	SHP	-0.136	-0.109	-0.049	0.036	0.136	0.252
BS	M-rf	-0.337	-0.127	-0.303	0.041	0.530	0.963
	Std	4.296	3.875	3.580	3.431	3.379	3.353
	SHP	-0.078	-0.033	-0.085	0.012	0.157	0.287
US	M-rf	0.133					
	Std	4.062					
	SHP	0.033					

TABLE 4-1--continued

B.

Period: 1985-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	2.008	1.831	1.653	1.476	1.298	1.121
	Std	4.968	4.815	4.719	4.682	4.707	4.793
	SHP	0.404	0.380	0.350	0.315	0.276	0.234
MV	M-rf	1.736	1.739	1.708	1.618	1.449	1.217
	Std	4.947	4.858	4.776	4.744	4.787	4.857
	SHP	0.351	0.358	0.358	0.341	0.308	0.254
TG	M-rf	2.337	2.266	2.055	1.838	1.618	1.371
	Std	5.627	5.343	5.080	4.960	4.888	5.165
	SHP	0.415	0.424	0.405	0.371	0.324	0.266
BS	M-rf	1.798	1.708	1.700	1.708	1.542	1.273
	Std	4.880	4.791	4.772	4.778	4.858	5.015
	SHP	0.358	0.367	0.367	0.357	0.317	0.254
US	M-rf	1.031					
	Std	5.417					
	SHP	0.185					

TABLE 4-1--continued

C.

Period: 1981-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	0.864	0.870	0.876	0.882	0.888	0.894
	Std	4.587	4.362	4.189	4.074	4.024	4.040
	SHP	0.188	0.199	0.209	0.217	0.221	0.221
MV	M-rf	0.864	0.904	0.982	1.068	1.137	1.178
	Std	4.478	4.363	4.236	4.129	4.051	4.040
	SHP	0.188	0.207	0.232	0.259	0.281	0.292
TG	M-rf	0.830	0.879	0.929	0.988	1.051	1.128
	Std	5.447	5.137	4.696	4.444	4.327	4.392
	SHP	0.152	0.171	0.198	0.222	0.243	0.257
BS	M-rf	0.723	0.815	0.723	0.874	1.036	1.118
	Std	4.660	4.403	4.283	4.180	4.478	4.243
	SHP	0.155	0.185	0.169	0.208	0.248	0.264
US	M-rf	0.587					
	Std	4.769					
	SHP	0.119					

Notes:
M-rf : Mean return - risk-free rate
Std : Standard deviation.
SHP : Sharpe's Performance Index

TABLE 4-2
PERFORMANCE OF INTERNATIONAL STOCK PORTFOLIOS: CANADIAN POINT OF VIEW

A.

Period: 1981-1984		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	-0.283	-0.116	0.051	0.218	0.385	0.552
	Std	3.553	3.405	3.289	3.208	3.164	3.159
	SHP	-0.080	-0.034	0.015	0.068	0.122	0.175
MV	M-rf	-0.203	-0.605	0.165	0.414	0.015	1.024
	Std	3.671	3.544	3.426	3.289	3.138	3.059
	SHP	-0.055	-0.013	0.048	0.126	0.228	0.335
TG	M-rf	-0.687	-0.605	-0.687	0.122	0.398	0.754
	Std	4.341	4.400	4.160	3.759	3.572	3.548
	SHP	-0.158	-0.138	-0.021	0.032	0.011	0.212
BS	M-rf	-0.524	-0.521	-0.158	0.011	0.371	0.831
	Std	3.573	3.416	3.159	3.289	3.232	3.326
	SHP	-0.147	-0.153	-0.050	0.003	0.015	0.250
CAN	M-rf	-0.391					
	Std	5.818					
	SHP	-0.067					

TABLE 4-2--continued

B.

Period: 1985-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	1.545	1.433	1.331	1.225	1.118	1.011
	Std	4.771	4.652	4.597	4.608	4.682	4.818
	SHP	0.324	0.309	0.290	0.266	0.239	0.210
MV	M-rf	1.432	1.448	1.440	1.386	1.269	1.107
	Std	4.637	4.592	4.570	4.610	4.728	4.882
	SHP	0.309	0.315	0.315	0.301	0.268	0.227
TG	M-rf	1.890	1.808	1.772	1.613	1.451	1.274
	Std	5.335	5.089	4.907	4.846	4.962	5.236
	SHP	0.354	0.371	0.361	0.333	0.293	0.243
BS	M-rf	1.408	1.433	1.459	1.461	1.374	1.169
	Std	4.730	4.620	4.618	4.688	4.828	5.043
	SHP	0.239	0.315	0.316	0.312	0.285	0.232
CAN	M-rf	0.369					
	Std	5.040					
	SHP	0.071					

TABLE 4-2--continued

C.

Period: 1981-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	0.631	0.641	0.651	0.721	0.751	0.781
	Std	4.253	4.163	4.006	3.964	3.980	4.053
	SHP	0.148	0.154	0.173	0.182	0.189	0.193
MV	M-rf	0.615	0.702	0.803	0.900	0.992	1.065
	Std	4.213	4.123	4.047	3.998	3.993	4.054
	SHP	0.146	0.170	0.198	0.225	0.248	0.263
TG	M-rf	0.602	0.641	0.842	0.868	0.925	1.014
	Std	4.970	4.858	4.591	4.355	4.317	4.450
	SHP	0.121	0.132	0.163	0.199	0.213	0.228
BS	M-rf	0.442	0.456	0.651	0.736	0.873	1.000
	Std	4.249	4.125	3.990	4.041	4.102	4.249
	SHP	0.104	0.110	0.163	0.182	0.213	0.235
CAN	M-rf	-0.016					
	Std	5.419					
	SHP	-0.003					

Notes:
M-rf : Mean return - risk-free rate
Std : Standard deviation.
SHP : Sharpe's Performance Index

TABLE 4-3
PERFORMANCE OF INTERNATIONAL STOCK PORTFOLIOS: FRENCH POINT OF VIEW

A.

Period: 1981-1984		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	1.287	1.222	1.156	1.090	1.025	0.959
	Std	3.738	3.565	3.420	3.307	3.230	3.191
	SHP	0.344	0.343	0.338	0.330	0.317	0.301
MV	M-rf	1.312	1.295	1.294	1.319	1.373	1.432
	Std	3.574	3.440	3.319	3.217	3.133	3.071
	SHP	0.367	0.377	0.390	0.410	0.438	0.466
TG	M-rf	1.080	1.067	1.061	1.080	1.094	1.145
	Std	4.900	4.520	4.173	3.875	3.689	3.589
	SHP	0.220	0.236	0.254	0.275	0.297	0.319
BS	M-rf	1.171	1.130	1.078	1.106	1.191	1.338
	Std	4.772	4.393	3.979	3.697	3.487	3.389
	SHP	0.245	0.257	0.271	0.299	0.342	0.395
FR	M-rf	0.819					
	Std	5.695					
	SHP	0.144					

TABLE 4-3--continued

B.

Period: 1985-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	0.765	0.820	0.875	0.930	0.985	1.040
	Std	5.149	5.065	4.993	4.933	4.885	4.849
	SHP	0.149	0.162	0.175	0.189	0.202	0.214
MV	M-rf	0.976	1.004	1.041	1.079	1.102	1.137
	Std	5.181	5.145	5.101	5.051	4.979	4.918
	SHP	0.189	0.195	0.204	0.214	0.221	0.231
TG	M-rf	1.304	1.352	1.327	1.304	1.299	1.287
	Std	5.504	5.386	5.302	5.273	5.279	5.305
	SHP	0.247	0.251	0.250	0.247	0.246	0.240
BS	M-rf	1.278	1.256	1.227	1.220	1.227	1.216
	Std	5.186	5.114	5.080	5.081	5.078	5.073
	SHP	0.246	0.246	0.242	0.246	0.242	0.240
FR	M-rf	1.485					
	Std	7.655					
	SHP	0.194					

TABLE 4-3--continued

C.

Period: 1981-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	1.026	1.021	1.016	1.010	1.005	1.000
	Std	4.487	4.364	4.261	4.180	4.120	4.083
	SHP	0.229	0.234	0.238	0.242	0.244	0.245
MV	M-rf	1.144	1.150	1.197	1.199	1.238	1.285
	Std	4.433	4.358	4.285	4.216	4.142	4.083
	SHP	0.256	0.264	0.272	0.284	0.299	0.315
TG	M-rf	1.220	1.210	1.199	1.184	1.197	1.216
	Std	5.184	4.946	4.746	4.603	4.530	4.505
	SHP	0.238	0.245	0.252	0.254	0.264	0.270
BS	M-rf	1.224	1.193	1.163	1.163	1.209	1.277
	Std	4.957	4.742	4.539	4.419	4.333	4.293
	SHP	0.247	0.252	0.254	0.263	0.279	0.298
FR	M-rf	1.150					
	Std	6.717					
	SHP	0.171					

Notes:
M-rf : Mean return - risk-free rate
Std : Standard deviation.
SHP : Sharpe's Performance Index

TABLE 4-4
PERFORMANCE OF INTERNATIONAL STOCK PORTFOLIOS: GERMAN POINT OF VIEW

A.

Period: 1981-1984		% hedged					
		0 %	40 %	50 %	60 %	80 %	100 %
EQ	M-rf	0.826	0.824	0.738	0.646	0.555	0.464
	Std	3.829	3.657	3.505	3.376	3.273	3.198
	SHP	0.240	0.227	0.210	0.191	0.170	0.145
MV	M-rf	0.843	0.826	0.824	0.839	0.889	0.935
	Std	3.423	3.351	3.284	3.224	3.175	3.111
	SHP	0.246	0.246	0.251	0.262	0.280	0.300
TG	M-rf	0.666	0.577	0.497	0.526	0.600	0.662
	Std	5.112	4.647	4.242	3.943	3.717	3.590
	SHP	0.130	0.124	0.117	0.133	0.161	0.185
BS	M-rf	0.871	0.602	0.392	0.497	0.557	0.769
	Std	5.256	4.681	3.978	3.705	3.480	3.388
	SHP	0.166	0.129	0.099	0.131	0.160	0.227
GER	M-rf	0.778					
	Std	4.123					
	SHP	0.189					

TABLE 4-4--continued

B.

Period: 1985-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	0.921	0.937	0.952	0.967	0.982	0.997
	Std	5.400	5.253	5.120	5.002	4.902	4.818
	SHP	0.178	0.178	0.186	0.193	0.200	0.207
MV	M-rf	1.158	1.147	1.122	1.115	1.098	1.093
	Std	5.400	5.329	5.242	5.128	4.992	4.878
	SHP	0.214	0.215	0.214	0.217	0.220	0.224
TG	M-rf	1.525	1.484	1.450	1.381	1.331	1.278
	Std	5.620	5.470	5.345	5.267	5.233	5.227
	SHP	0.271	0.271	0.271	0.262	0.250	0.245
BS	M-rf	1.492	1.385	1.328	1.282	1.236	1.168
	Std	5.745	5.234	5.155	5.124	5.102	5.047
	SHP	0.250	0.265	0.258	0.250	0.242	0.231
GER	M-rf	1.019					
	Std	7.485					
	SHP	0.136					

TABLE 4-4--continued

C.

Period: 1981-1988							
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	0.920	0.883	0.845	0.807	0.769	0.731
	Std	4.658	4.503	4.364	4.245	4.146	4.070
	SHP	0.199	0.196	0.194	0.190	0.185	0.180
MV	M-rf	1.001	0.988	0.973	0.980	0.993	1.014
	Std	4.497	4.428	4.351	4.261	4.161	4.070
	SHP	0.222	0.223	0.224	0.230	0.239	0.249
TG	M-rf	1.095	1.030	0.974	0.954	0.965	0.970
	Std	5.351	5.058	4.811	4.637	4.521	4.463
	SHP	0.205	0.204	0.202	0.204	0.214	0.217
BS	M-rf	1.001	0.993	0.860	0.904	0.897	0.968
	Std	5.479	4.945	4.592	4.455	4.348	4.276
	SHP	0.216	0.201	0.187	0.199	0.206	0.226
GER	M-rf	0.898					
	Std	6.011					
	SHP	0.149					

Notes:
M-rf : Mean return - risk-free rate
Std : Standard deviation.
SHP : Sharpe's Performance Index

TABLE 4-5
PERFORMANCE OF INTERNATIONAL STOCK PORTFOLIOS: JAPANESE POINT OF VIEW

A.

Period: 1981-1984		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	0.520	0.509	0.499	0.488	0.477	0.466
	Std	3.137	3.033	2.995	3.025	3.121	3.278
	SHP	0.166	0.168	0.166	0.161	0.153	0.142
MV	M-rf	0.813	0.813	0.812	0.831	0.878	0.936
	Std	3.211	3.139	3.075	3.039	3.051	3.154
	SHP	0.253	0.259	0.264	0.273	0.288	0.297
TG	M-rf	0.699	0.597	0.532	0.499	0.548	0.648
	Std	3.615	3.477	3.402	3.374	3.415	3.556
	SHP	0.193	0.172	0.156	0.148	0.160	0.182
BS	M-rf	0.786	0.709	0.497	0.556	0.633	0.762
	Std	3.519	3.315	3.254	3.240	3.252	3.342
	SHP	0.223	0.181	0.153	0.172	0.195	0.228
JAP	M-rf	1.131					
	Std	4.321					
	SHP	0.262					

TABLE 4-5--continued

B.

Period: 1985-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	0.675	0.755	0.835	0.915	0.996	1.076
	Std	5.428	5.257	5.110	4.989	4.897	4.834
	SHP	0.124	0.144	0.163	0.183	0.203	0.223
MV	M-rf	1.085	1.124	1.154	1.162	1.164	1.172
	Std	4.920	4.966	4.992	4.978	4.938	4.898
	SHP	0.221	0.226	0.231	0.233	0.236	0.239
TG	M-rf	1.418	1.424	1.408	1.371	1.361	1.325
	Std	5.050	5.055	5.073	5.108	5.167	5.224
	SHP	0.281	0.282	0.277	0.268	0.263	0.254
BS	M-rf	1.325	1.320	1.312	1.300	1.274	1.229
	Std	4.892	4.895	4.927	4.969	5.029	5.047
	SHP	0.271	0.270	0.268	0.262	0.253	0.244
JAP	M-rf	1.085					
	Std	5.672					
	SHP	0.350					

TABLE 4-5--continued

C.

Period: 1981-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	1.003	1.037	1.072	1.107	1.141	1.176
	Std	4.410	4.269	4.167	4.106	4.088	4.114
	SHP	0.227	0.243	0.257	0.270	0.279	0.286
MV	M-rf	1.354	1.374	1.388	1.402	1.426	1.459
	Std	4.133	4.133	4.125	4.103	4.083	4.098
	SHP	0.328	0.332	0.336	0.342	0.349	0.356
TG	M-rf	1.464	1.416	1.375	1.340	1.359	1.392
	Std	4.376	4.327	4.311	4.320	4.368	4.452
	SHP	0.334	0.327	0.319	0.310	0.314	0.313
BS	M-rf	1.461	1.366	1.310	1.333	1.359	1.400
	Std	4.243	4.167	4.165	4.182	4.218	4.260
	SHP	0.314	0.328	0.314	0.319	0.328	0.329
JAP	M-rf	1.963					
	Std	5.026					
	SHP	0.391					

Notes:
M-rf : Mean return - risk-free rate
Std : Standard deviation.
SHP : Sharpe's Performance Index

TABLE 4-6
PERFORMANCE OF INTERNATIONAL STOCK PORTFOLIOS: SWISS POINT OF VIEW

A.

Period: 1981-1984		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	0.987	0.885	0.783	0.681	0.579	0.477
	Std	3.928	3.720	3.541	3.396	3.290	3.226
	SHP	0.201	0.238	0.221	0.201	0.176	0.148
MV	M-rf	0.679	0.728	0.787	0.774	0.906	0.947
	Std	3.248	3.228	3.290	3.088	3.153	3.122
	SHP	0.209	0.226	0.245	0.251	0.287	0.303
TG	M-rf	0.665	0.614	0.524	0.540	0.581	0.640
	Std	5.071	4.599	4.163	3.872	3.656	3.549
	SHP	0.131	0.133	0.126	0.140	0.159	0.180
BS	M-rf	0.482	0.464	0.456	0.498	0.603	0.648
	Std	4.994	4.649	3.969	3.691	3.460	3.302
	SHP	0.096	0.100	0.115	0.135	0.174	0.196
SW	M-rf	0.451					
	Std	2.987					
	SHP	0.151					

TABLE 4-6--continued

B.

Period: 1985-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	1.018	1.017	1.018	1.013	1.018	1.009
	Std	5.715	5.492	5.287	5.100	4.935	4.795
	SHP	0.178	0.185	0.192	0.199	0.205	0.210
MV	M-rf	1.354	1.313	1.259	1.220	1.144	1.105
	Std	5.446	5.350	5.271	5.156	5.005	4.861
	SHP	0.249	0.245	0.239	0.237	0.229	0.227
TG	M-rf	1.735	1.649	1.567	1.473	1.395	1.297
	Std	5.672	5.528	5.402	5.311	5.254	5.204
	SHP	0.306	0.298	0.290	0.277	0.265	0.249
BS	M-rf	1.596	1.528	1.446	1.359	1.286	1.188
	Std	5.402	5.296	5.296	5.148	5.113	5.034
	SHP	0.265	0.290	0.277	0.264	0.252	0.236
SW	M-rf	0.858					
	Std	6.034					
	SHP	0.142					

TABLE 4-6--continued

C.

Period: 1981-1988							
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	1.332	1.280	1.228	1.176	1.124	1.072
	Std	4.878	4.666	4.478	4.312	4.176	4.071
	SHP	0.273	0.274	0.274	0.273	0.269	0.263
MV	M-rf	1.346	1.350	1.352	1.326	1.350	1.355
	Std	4.470	4.402	4.345	4.231	4.161	4.064
	SHP	0.301	0.307	0.311	0.313	0.325	0.333
TG	M-rf	1.529	1.461	1.375	1.336	1.317	1.298
	Std	5.374	5.080	4.821	4.642	4.517	4.440
	SHP	0.280	0.269	0.285	0.288	0.292	0.292
BS	M-rf	1.368	1.325	1.280	1.257	1.274	1.247
	Std	5.203	4.981	4.626	4.472	4.352	4.240
	SHP	0.263	0.269	0.277	0.281	0.293	0.294
SW	M-rf	0.983					
	Std	4.738					
	SHP	0.208					

Notes:
M-rf : Mean return - risk-free rate
Std : Standard deviation.
SHP : Sharpe's Performance Index

TABLE 4-7
PERFORMANCE OF INTERNATIONAL STOCK PORTFOLIOS: U.K. POINT OF VIEW

A.

Period: 1981-1984		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	1.226	1.086	0.946	0.805	0.665	0.524
	Std	3.824	3.616	3.449	3.328	3.260	3.246
	SHP	0.321	0.300	0.274	0.242	0.204	0.162
MV	M-rf	1.253	1.170	1.103	1.043	1.001	0.996
	Std	4.126	3.923	3.692	3.457	3.260	3.117
	SHP	0.304	0.298	0.299	0.302	0.309	0.319
TG	M-rf	0.871	0.681	0.679	0.632	0.693	0.730
	Std	4.547	4.265	3.910	3.674	3.568	3.560
	SHP	0.191	0.160	0.174	0.172	0.191	0.205
BS	M-rf	0.798	0.672	0.633	0.701	0.759	0.820
	Std	4.508	4.127	3.666	3.496	3.375	3.332
	SHP	0.177	0.163	0.173	0.201	0.225	0.246
UK	M-rf	1.179					
	Std	4.868					
	SHP	0.242					

TABLE 4-7--continued

B.

Period: 1985-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	0.696	0.788	0.842	0.915	0.988	1.061
	Std	5.215	5.056	4.933	4.849	4.806	4.806
	SHP	0.133	0.162	0.171	0.189	0.246	0.221
MV	M-rf	0.788	0.862	0.985	1.072	1.111	1.158
	Std	4.852	4.841	4.842	4.866	4.857	4.878
	SHP	0.162	0.182	0.203	0.220	0.229	0.237
TG	M-rf	1.317	1.308	1.322	1.322	1.335	1.324
	Std	5.595	5.431	5.231	5.105	5.102	5.206
	SHP	0.235	0.241	0.253	0.259	0.262	0.254
BS	M-rf	1.068	1.134	1.210	1.220	1.245	1.222
	Std	5.011	4.964	4.976	4.953	4.989	5.039
	SHP	0.213	0.228	0.243	0.246	0.249	0.243
UK	M-rf	0.604					
	Std	6.136					
	SHP	0.098					

TABLE 4-7--continued

C.

Period: 1981-1988		% hedged					
		0 %	20 %	40 %	60 %	80 %	100 %
EQ	M-rf	1.797	1.764	1.730	1.696	1.663	1.629
	Std	4.558	4.376	4.234	4.137	4.087	4.087
	SHP	0.394	0.403	0.404	0.410	0.407	0.399
MV	M-rf	1.857	1.862	1.830	1.893	1.893	1.913
	Std	4.487	4.386	4.284	4.108	4.108	4.072
	SHP	0.414	0.425	0.439	0.451	0.461	0.470
TG	M-rf	1.930	1.831	1.837	1.813	1.850	1.863
	Std	5.075	4.866	4.603	4.435	4.389	4.445
	SHP	0.380	0.376	0.389	0.409	0.422	0.419
BS	M-rf	1.759	1.728	1.758	1.797	1.838	1.858
	Std	4.745	4.549	4.355	4.270	4.242	4.252
	SHP	0.371	0.380	0.404	0.421	0.433	0.437
UK	M-rf	1.728					
	Std	5.518					
	SHP	0.313					

Notes:
M-rf : Mean return - risk-free rate
Std : Standard deviation.
SHP : Sharpe's Performance Index

a certain country, who dominates the other investment strategies. However, all the investment strategies from the perspectives of the German and the Swiss do not belong to the SSD efficient set. The unhedged EW, MV, BS, 100% hedged MV, TG and the BS strategies from the point of view of the Canadian investor are in the SSD efficient set. The 100% hedged MV, TG and BS strategies from the perspective of the French investor are in the SSD efficient set. The unhedged MV, TG, BS strategies, and the domestic Japanese market investment from the perspective of the Japanese investor, are in the SSD efficient set. From the point of view of the UK investor, the 100% hedged TG, and BS strategies are in the SSD efficient. The unhedged EW, MV and the 100% hedged TG, and BS strategies are in the SSD efficient set from the point of view of the U.S. investor. Using Third Degree Stochastic Dominance (TSD), it is found out that the only investment strategy that was previously in the SSD efficient set but is no longer in the TSD efficient set is the unhedged EW strategy from the perspective of the U.S. investor.

In doing the above analysis, it is realized that the mean returns and the standard deviations of the real portfolio returns are not stationary over time. For example, the Japanese stock market has declined substantially for the past few months. However, this analysis is useful to compare the performances of the various unhedged and 100% hedged investment strategies from the perspectives of the investors

from the various countries for the period 1981-89. The results show that for this period, both the unhedged and 100% hedged strategies may be included in the SSD efficient sets from the perspective of a certain investor, but not so from the perspectives of other investors.

Summary

This essay shows that the forward exchange bias affects the mean returns of the unhedged and hedged strategies from the perspectives of investors from the U.S. and Canada in different periods. Over a long period of time, the mean returns from the hedged and unhedged portfolios are not very much different from each other. Using stochastic dominance as performance measures, it is found out that both the unhedged and hedged strategies may be included in the SSD efficient sets from the perspective of an investor from a certain country, but not so from the perspectives of investors from other countries.

CHAPTER 5
SUMMARY OF CONCLUSIONS

Essay I shows that there are significant price differences between the underlying securities and the portfolios of STRIPS. There are relatively more price differences between nonstrippable securities and the portfolios of STRIPS than between strippable securities and the portfolios of STRIPS. The variability of the price differences between the underlying nonstrippable securities and the portfolios of STRIPS is significantly greater than the variability of the price differences between underlying strippable securities and the portfolios of STRIPS. Because of the lower price disparities in the strippable securities market, stripping by the book entry method has brought prices of the underlying strippable securities close to the prices of the portfolios of STRIPS.

Essay II shows that the cross-sectional autoregressive model and the autoregressive moving average model do not appreciably outperform the random walk with drift model of stock prices in forecasting future stock returns. The investment strategy using the cross-sectional autoregressive model does not yield abnormal returns to the investor for the sample of securities used in this study, after accounting for

transaction costs. It is also shown that bid-ask errors account for a large proportion of the autocorrelation in the cross-sectional autoregressive model. The highest ranked portfolio based on predicted return from the cross-sectional autoregreesive model does not show abnormal returns (even before accounting for transaction costs) when bid-bid returns are used to estimate the coefficients of the model.

Essay III shows that the forward exchange bias affects the mean returns of hedged and unhedged international investments for those investors from the U.S. and Canada. The mean portfolio returns of the hedged and unhedged international investments are not very much different from each other for most investment strategies for investors from countries other than the U.S. and Canada.

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BIOGRAPHICAL SKETCH

Kok Chew Lim was born in Kuala Lumpur, Malaysia, on August 15 1961. He holds a Bachelor of Engineering in Civil Engineering (second class honours, lower division, 1985) from the National University of Singapore, Singapore, and a Master of Business Administration (1988) from Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Roy Crum, Chairman
Professor of Finance,
Insurance, and Real Estate

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Haim Levy, Cochairman
Graduate Research Professor
of Finance, Insurance, and
Real Estate

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Miles Livingston
Professor of Finance,
Insurance, and Real Estate

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Robert Emerson
Professor of Food and
Resource Economics

This dissertation was submitted to the Graduate Faculty of the Department of Finance, Insurance, and Real Estate in the College of Business Administration and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Dean, Graduate School